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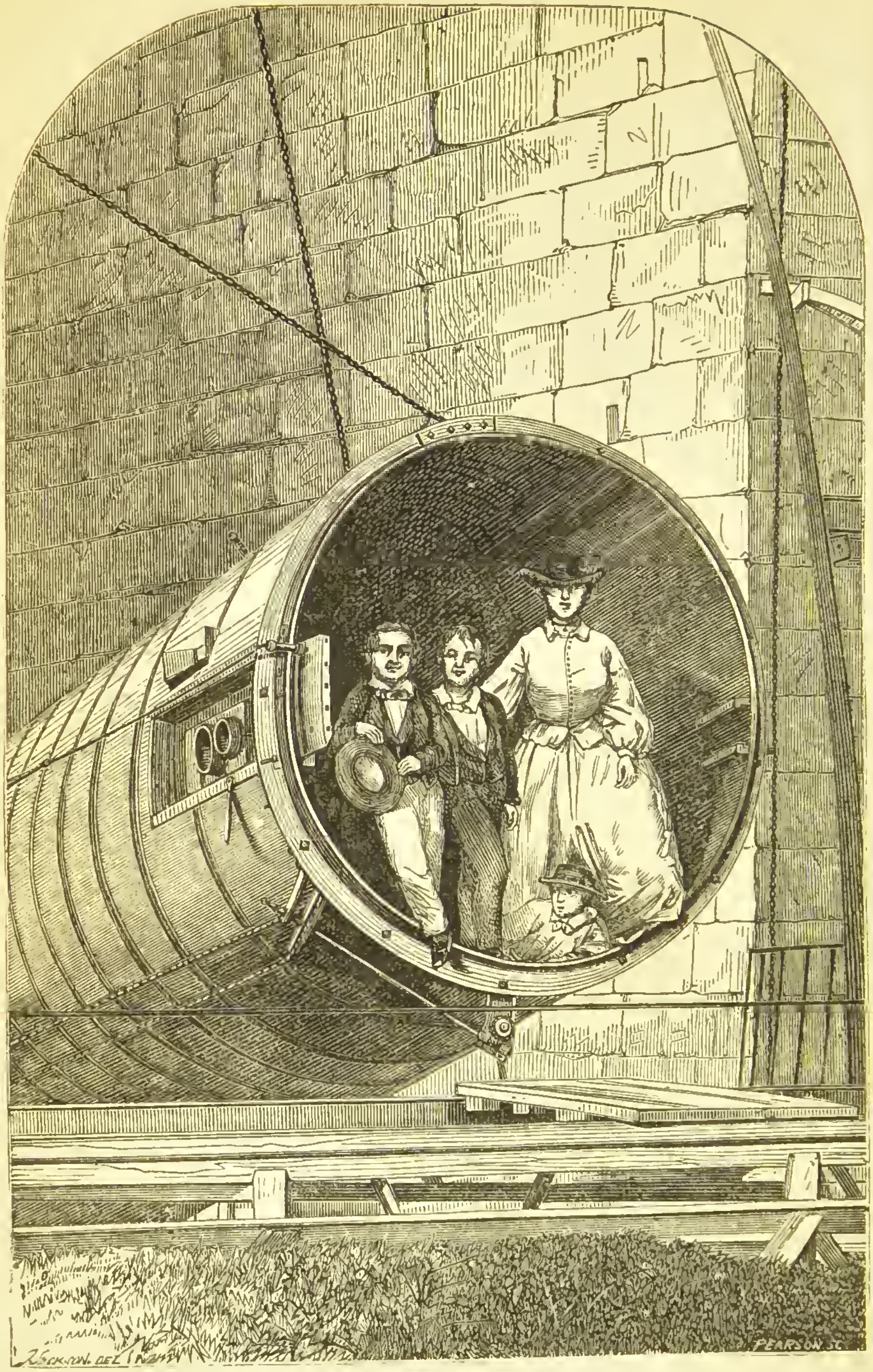


MOUTH OF THE GREAT ROSSE TELESCOPE, AT PARSONSTOWN.
FROM A PHOTOGRAPH.

87971.

Things not generally Known

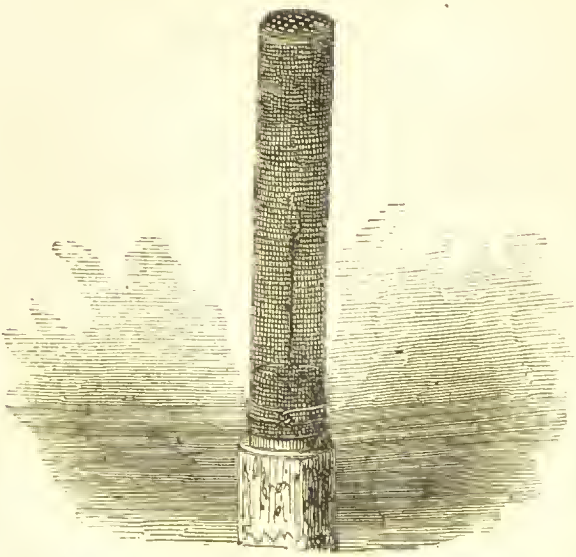
CURIOSITIES OF SCIENCE,

Past and Present.

A BOOK FOR OLD AND YOUNG.

By JOHN TIMBS, F.S.A.,

AUTHOR OF "THINGS NOT GENERALLY KNOWN;" AND EDITOR OF "THE YEAR-BOOK OF FACTS."



Model of the Safety-Lamp, made by Sir Humphry Davy's own hands in the possession of the Royal Society.

Fifth Edition.

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Gentle Reader,

The volume of "Curiosities" which I here present to your notice is a portion of the result of a long course of reading, observation, and research, necessary for the compilation of thirty volumes of "Arcana of Science" and "Year-Book of Facts," published from 1828 to 1858. Throughout this period—nearly half of the Psalmist's "days of our years"—I have been blessed with health and strength to produce these volumes, year by year (with one exception), upon the appointed day; and this with unbroken attention to periodical duties, frequently rendered harassing or ungenial. Nevertheless, during these three decades I have found my account in the increasing approbation of the reading public, which has been so largely extended to the series of "Things not generally Known," of which the present volume of "Curiosities of Science" is an instalment. I need scarcely add, that in its progressive preparation I have endeavoured to compare, weigh, and consider, the contents, so as to combine the experience of the Past with the advantages of the Present.

In these days of universal attainments, when Science becomes not merely a luxury to the rich, but bread to the poor, and when the very amusements as well as the conveniences of life have taken a scientific colour, it is reasonable to hope that the present volume may be acceptable to a large class of seekers after "things not generally known." For this purpose, I have aimed at soundness as well as popularity; although, for myself, I can claim little beyond being one of those industrious "ants of science" who garner facts, and by selection and comparison adapt them for a wider circle of readers than they were originally expected to reach. In each case, as far as possible, these "Curiosities" bear the mint-mark of authority; and in the living list are prominent the names of Humboldt and Herschel, Airy and Whewell, Faraday, Brewster, Owen, and Agassiz, Maury, Wheatstone, and Hunt, from whose writings and researches the following pages are frequently enriched.

The sciences here illustrated are, in the main, Astronomy and Meteorology; Geology and Paleontology; Physical Geography; Sound, Light, and Heat; Magnetism and Electricity,—the latter with special attention to the great marvel of our times, the Electro-magnetic Telegraph. I hope, at no very distant period, to extend the "Curiosities" to another volume, to include branches of Natural and Experimental Science which are not here presented.

I. T.

January 1859

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THE GREAT ROSSE TELESCOPE.

The originator and architect of this magnificent instrument had long been distinguished in scientific research as Lord Oxmantown; and may be considered to have gracefully commemorated his succession to the Earldom of Rosse, and his Presidency of the Royal Society, by the completion of this marvellous work, with which his name will be hereafter indissolubly associated.

The Great Reflecting Telescope at Birr Castle (of which the Frontispiece represents a portion[*]) will be found fully described at pp. 96-99 of the present volume of *Curiosities of Science.*

This matchless instrument has already disclosed "forms of stellar arrangement indicating modes of dynamic action never before contemplated in celestial mechanics." "In these departments of research,—the examination of the configurations of nebulæ, and the resolution of nebulæ into stars (says the Rev. Dr. Scoresby),—the six-feet speculum has had its grandest triumphs, and the noble artificer and observer the highest rewards of his talents and enterprise. Altogether, the quantity of work done during a period of about seven years—including a winter when a noble philanthropy for a starving population absorbed the keenest interests of science—has been decidedly great; and the new knowledge acquired concerning the handiwork of the great Creator amply satisfying of even sanguine expectation."

The Vignette.

SIR HUMPHRY DAVY'S OWN MODEL OF HIS SAFETY-LAMP.

Of the several contrivances which have been proposed for safely lighting coal-mines subject to the visitation of fire-damp, or carburetted hydrogen, the Safety-Lamp of Sir Humphry Davy is the only one which has ever been judged safe, and been extensively employed. The inventor first turned his attention to the subject in 1815, when Davy began a minute chemical examination of fire-damp, and found that it required an admixture of a large quantity of atmospheric air to render it explosive. He then ascertained that explosions of inflammable gases were incapable of being passed through long narrow metallic tubes, and that this principle of security was still obtained by diminishing their length and increasing their number. This fact led to trials upon sieves made of wire-gauze; when Davy found that if a piece of wire-gauze was held over the flame of a lamp, or of coal-gas, it prevented the flame from passing; and he ascertained that a flame confined in a cylinder of very fine wire-gauze did not explode even in a mixture of oxygen and hydrogen, but that the gases burnt in it with great vivacity.

These experiments served as the basis of the Safety-Lamp. The apertures in the gauze, Davy tells us in his work on the subject, should not be more than $\frac{1}{22}$d of an inch square. The lamp is screwed on to the bottom of the wire-gauze cylinder. When it is lighted, and gradually introduced into an atmosphere mixed with fire-damp, the size and length of the flame are first increased. When the inflammable gas forms as much as $\frac{1}{12}$th of the volume of air, the cylinder becomes filled with a feeble blue flame, within which the flame of the wick burns brightly, and the light of the wick continues till the fire-damp increases to $\frac{1}{6}$th or $\frac{1}{5}$th;

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[*] From a photograph, with figures, to show the relative size of the tube aperture.

it is then lost in the flame of the fire-damp, which now fills the cylinder with a pretty strong light; and when the foul air constitutes one-third of the atmosphere it is no longer fit for respiration,—and this ought to be a signal to the miner to leave that part of the workings.

Sir Humphry Davy presented his first communication respecting his discovery of the Safety-Lamp to the Royal Society in 1815. This was followed by a series of papers remarkable for their simplicity and clearness, crowned by that read on the 11th of January 1816, when the principle of the Safety-Lamp was announced, and Sir Humphry presented to the Society a model made by his own hands, which is to this day preserved in the collection of the Royal Society at Burlington House. From this interesting memorial the Vignette has been sketched.

There have been several modifications of the Safety-Lamp, and the merit of the discovery has been claimed by others, among whom was Mr. George Stephenson; but the question was set at rest forty-one years since by an examination,—attested by Sir Joseph Banks, P.R.S., Mr. Brande, Mr. Hatchett, and Dr. Wollaston,—and awarding the independent merit to Davy.

A more substantial, though not a more honourable, testimony of approval was given by the coal-owners, who subscribed 2500*l.* to purchase a superb service of plate, which was suitably inscribed and presented to Davy.*

Meanwhile the Report by the Parliamentary Committee "cannot admit that the experiments (made with the Lamp) have any tendency to detract from the character of Sir Humphry Davy, or to disparage the fair value placed by himself upon his invention. The improvements are probably those which longer life and additional facts would have induced him to contemplate as desirable, and of which, had he not been the inventor, he might have become the patron."

The principle of the invention may be thus summed up. In the Safety-Lamp, the mixture of the fire-damp and atmospheric air within the cage of wire-gauze explodes upon coming in contact with the flame; but the combustion cannot pass through the wire-gauze, and being there imprisoned, cannot impart to the explosive atmosphere of the mine any of its force. This effect has been erroneously attributed to a cooling influence of the metal.

Professor Playfair has eloquently described the Safety-Lamp of Davy as a present from philosophy to the arts; a discovery in no degree the effect of accident or chance, but the result of patient and enlightened research, and strongly exemplifying the great use of an immediate and constant appeal to experiment. After characterising the invention as the *shutting-up in a net of the most slender texture* a most violent and irresistible force, and a power that in its tremendous effects seems to emulate the lightning and the earthquake, Professor Playfair thus concludes: "When to this we add the beneficial consequences, and the saving of the lives of men, and consider that the effects are to remain as long as coal continues to be dug from the bowels of the earth, it may be fairly said that there is hardly in the whole compass of art or science a single invention of which one would rather wish to be the author. . . . This," says Professor Playfair, "is exactly such a case as we should choose to place before Bacon, were he to revisit the earth; in order to give him, in a small compass, an idea of the advancement which philosophy has made since the time when he had pointed out to her the route which she ought to pursue."

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* Weld's *History of the Royal Society*, vol. ii. p. 188.

CURIOSITIES OF SCIENCE.

Introductory.

SCIENCE OF THE ANCIENT WORLD.

In every province of human knowledge where we now possess a careful and coherent interpretation of nature, men began by attempting in bold flights to leap from obvious facts to the highest point of generality—to some wide and simple principle which after-ages had to reject. Thus, from the facts that all bodies are hot or cold, moist or dry, they leapt at once to the doctrine that the world is constituted of four elements—earth, air, fire, water; from the fact that the heavenly bodies circle the sky in courses which occur again and again, they at once asserted that they move in exact circles, with an exactly uniform motion; from the fact that heavy bodies fall through the air somewhat faster than light ones, it was assumed that all bodies fall quickly or slowly exactly in proportion to their weight; from the fact that the magnet attracts iron, and that this force of attraction is capable of increase, it was inferred that a perfect magnet would have an irresistible force of attraction, and that the magnetic pole of the earth would draw the nails out of a ship's bottom which came near it; from the fact that some of the finest quartz crystals are found among the snows of the Alps, it was inferred that the crystallisation of gems is the result of intense and long-continued cold: and so on in innumerable instances. Such anticipations as these constituted the basis of almost all the science of the ancient world; for such principles being so assumed, consequences were drawn from them with great ingenuity, and systems of such deductions stood in the place of science.—*Edinburgh Review*, No. 216.

SCIENCE AT OXFORD AND CAMBRIDGE.

The earliest science of a decidedly English school is due, for the most part, to the University of Oxford, and specially to Merton College,—a foundation of which Wood remarks, that there was no other for two centuries, either in Oxford or Paris, which could at all come near it in the cultivation of the sciences. But he goes on to say that large chests full of the writers of this college were allowed to remain untouched by their successors for fear of the magic which was supposed to be contained in them. Nevertheless, it is not difficult to trace the liberalising effect of scientific study upon the University in general, and Merton College in particular; and it must be remembered that to the cultivation of the mind at Oxford we owe almost all the literary celebrity of the middle ages. In this period the University of Cambridge appears to have acquired no scientific distinction. Taking as a test the acquisition of celebrity on the continent, we find that Bacon, Sacrobosco, Greathead, Estwood, &c. were all of Oxford. The latter University had its morning of splendour while Cambridge was comparatively unknown; it had also its noonday, illustrated by such men as Briggs, Wren, Wallis, Halley, and Bradley.

The age of science at Cambridge may be said to have begun with Francis Bacon; and but that we think much of the difference between him and his celebrated namesake lies more in time and circumstances than in talents or feelings, we would rather date from 1600 with the former than from 1250 with the latter. Praise or blame on either side is out of the question, seeing that the earlier foundation of Oxford, and its superiority in pecuniary means, rendered all that took place highly probable; and we are in a great measure indebted for the liberty of writing our thoughts, to the cultivation of the liberalising sciences at Oxford in the dark ages.

With regard to the University of Cambridge, for a long time there hardly existed the materials of any proper instruction, even to the extent of pointing out what books should be read by a student desirous of cultivating astronomy.

PLATO'S SURVEY OF THE SCIENCES.

Plato, like Francis Bacon, took a review of the sciences of his time: he enumerates arithmetic and plane geometry, treated as collections of abstract and permanent truths; solid geometry, which he "notes as deficient" in his time, although in fact he and his school were in possession of the doctrine of the "five regular solids;" astronomy, in which he demands a science which should be elevated above the mere knowledge of phenomena. The visible appearances of the heavens only suggest the problems with which true astronomy deals; as beautiful geometrical diagrams do not prove, but only suggest geometrical propositions. Finally, Plato notices the subject of harmonics, in which he requires a science which shall deal with truths more exact than the ear can establish, as in astronomy he requires truths more exact than the eye can assure us of.

In a subsequent paper Plato speaks of *Dialectic* as a still higher element of a philosophical education, fitted to lead men to the knowledge of real existences and of the supreme good. Here he describes dialectic by its objects and purpose. In other places dialectic is spoken of as a method or process of analysis; as in the *Phædrus,* where Socrates describes a good dialectician as one who can divide a subject according to its natural members, and not miss the joint, like a bad carver. Xenophon says that Socrates derived *dialectic* from a term implying to *divide a subject into parts,* which Mr. Grote thinks unsatisfactory as an etymology, but which has indicated a practical connection in the Socratic school. The result seems to be that Plato did not establish any method of analysis of a subject as his dialectic; but he conceived that the analytical habits formed by the comprehensive study of the exact sciences, and sharpened by the practice of dialogue, would lead his students to the knowledge of first principles.—*Dr. Whewell.*

FOLLY OF ATHEISM.

Morphology, in natural science, teaches us that the whole animal and vegetable creation is formed upon certain fundamental types and patterns, which can be traced under various modifications and transformations through all the rich variety of things apparently of most dissimilar build. But here and there a scientific person takes it into his foolish head that there may be a set of moulds without a moulder, a calculated gradation of forms without a calculator, an ordered world without an ordering God. Now, this atheistical science conveys about as much meaning as suicidal life: for science is possible only where there are ideas, and ideas are only possible where there is mind, and minds are the offspring of God; and atheism itself is not merely ignorance and stupidity,—it is the purely nonsensical and the unintelligible.—*Professor Blackie; Edinburgh Essays,* 1856.

THE ART OF OBSERVATION.

To observe properly in the very simplest of the physical sciences requires a long and severe training. No one knows this so feelingly as the great discoverer. Faraday once said, that he always doubts his own observations. Mitscherlich on one occasion remarked to a man of science that it takes fourteen years to discover and establish a single new fact in chemistry. An enthusiastic student one day betook himself to Baron Cuvier with the exhibition of a new organ—a muscle which he supposed himself to have discovered in the body of some living creature or other; but the experienced and sagacious naturalist kindly bade the young man return to him with the same discovery in six months. The Baron would not even listen to the student's demonstration, nor examine his dissection, till the eager and youthful discoverer had hung over the object of inquiry for half a year; and yet that object was a mere thing of the senses.—*North-British Review*, No. 18.

MUTUAL RELATIONS OF PHENOMENA.

In the observation of a phenomenon which at first sight appears to be wholly isolated, how often may be concealed the germ of a great discovery! Thus, when Galvani first stimulated the nervous fibre of the frog by the accidental contact of two heterogeneous metals, his contemporaries could never have anticipated that the action of the voltaic pile would discover to us in the alkalies metals of a silver lustre, so light as to swim on water, and eminently inflammable; or that it would become a powerful instrument of chemical analysis, and at the same time a thermoscope and a magnet. When Huyghens first observed, in 1678, the phenomenon of the polarisation of light, exhibited in the difference between two rays into which a pencil of light divides itself in passing through a doubly refracting crystal, it could not have been foreseen that a century and a half later the great philosopher Arago would, by his discovery of *chromatic polarisation*, be led to discern, by means of a small fragment of Iceland spar, whether solar light emanates from a solid body or a gaseous covering; or whether comets transmit light directly, or merely by reflection.—*Humboldt's Cosmos*, vol. i.

PRACTICAL RESULTS OF THEORETICAL SCIENCE.

What are the great wonders, the great sources of man's material strength, wealth, and comfort in modern times? The Railway, with its mile-long trains of men and merchandise, moving with the velocity of the wind, and darting over chasms a thousand feet wide; the Electric Telegraph, along which man's thoughts travel with the velocity of light, and girdle the earth more quickly than Puck's promise to his master; the contrivance by which the Magnet, in the very middle of a strip of iron, is still true to the distant pole, and remains a faithful guide to the mariner; the Electrotype process, by which a metallic model of any given object, unerringly exact, grows into being like a flower. Now, all these wonders are the result of recent and profound discoveries in theoretical science. The Locomotive Steam-engine, and the Steam-engine in all its other wonderful and invaluable applications, derives its efficacy from the discoveries, by Watt and others, of the laws of steam. The Railway Bridge is not made strong by mere accumulation of materials, but by the most exact and careful scientific examination of the means of giving the requisite strength to every part, as in the great example of Mr. Stephenson's Britannia Bridge over the Menai Strait. The Correction of the Magnetic Needle in iron ships it would have been impossible for Mr. Airy to secure without a complete theoretical knowledge of the laws of Magnetism. The Electric Telegraph and the Electrotype process include in their principles and mechanism the most complete and subtle results of electrical and magnetical theory.—*Edinburgh Review*, No. 216.

PERPETUITY OF IMPROVEMENT.

In the progress of society all great and real improvements are perpetuated: the same corn which, four thousand years ago, was raised from an improved grass by an inventor worshiped for two thousand years in the ancient world under the name of Ceres, still forms the principal food of mankind; and the potato, perhaps the greatest benefit that the old has derived from the new world, is spreading over Europe, and will continue to nourish an extensive population when the name of the race by whom it was first cultivated in South America is forgotten.—*Sir H. Davy.*

THE EARLIEST ENGLISH SCIENTIFIC TREATISE.

Geoffrey Chaucer, the poet, wrote a treatise on the Astrolabe for his son, which is the earliest English treatise we have met with on any scientific subject. It was not completed; and the apologies which Chaucer makes to his own child for writing in English are curious; while his inference that his son should therefore "pray God save the king that is lord of this language," is at least as loyal as logical.

PHILOSOPHERS' FALSE ESTIMATES OF THEIR OWN LABOURS

Galileo was confident that the most important part of his contributions to the knowledge of the solar system was his Theory of the Tides—a theory which all succeeding astronomers have rejected as utterly baseless and untenable. Descartes probably placed far above his beautiful explanation of the rainbow, his *à priori* theory of the existence of the vortices which caused the motion of the planets and satellites. Newton perhaps considered as one of the best parts of his optical researches his explanation of the natural colour of bodies, which succeeding optical philosophers have had to reject; and he certainly held very strongly the necessity of a material cause for gravity, which his disciples have disregarded. Davy looked for his greatest triumph in the application of his discoveries to prevent the copper bottoms of ships from being corroded. And so in other matters.—*Edinburgh Review*, No. 216.

RELICS OF GENIUS.

Professor George Wilson, in a lecture to the Scottish Society of Arts, says: "The spectacle of these things ministers only to the good impulses of humanity. Isaac Newton's telescope at the Royal Society of London; Otto Guericke's air-pump in the Library at Berlin; James Watt's repaired Newcomen steam-engine in the Natural-Philosophy class-room of the College at Glasgow; Fahrenheit's thermometer in the corresponding class-room of the University of Edinburgh; Sir H. Davy's great voltaic battery at the Royal Institution, London, and his safety-lamp at the Royal Society; Joseph Black's pneumatic trough in Dr. Gregory's possession; the first wire which Faraday made rotate electro-magnetically, at St. Bartholomew's Hospital; Dalton's atomic models at Manchester; and Kemp's liquefied gases in the Industrial Museum of Scotland,—are alike personal relics, historical monuments, and objects of instruction, which grow more and more precious every year, and of which we never can have too many."

THE ROYAL SOCIETY: THE NATURAL AND SUPERNATURAL.

The Royal Society was formed with the avowed object of increasing knowledge by direct experiment; and it is worthy of remark, that the charter granted by Charles II. to this celebrated institution declares that its object is the extension of natural knowledge, as opposed to that which is supernatural.

Dr. Paris (*Life of Sir H. Davy*, vol. ii. p. 178) says: "The charter of the Royal Society states that it was established for the improvement of *natural* science. This epithet *natural* was originally intended to imply a meaning, of which very few persons, I believe, are aware. At the period of the establishment of the society, the arts of witchcraft and divination were very extensively encouraged; and the word *natural* was therefore introduced in contradistinction to *supernatural*."

THE PHILOSOPHER BOYLE.

After the death of Bacon, one of the most distinguished Englishmen was certainly Robert Boyle, who, if compared with his contemporaries, may be said to rank immediately below Newton, though of course very inferior to him as an original thinker. Boyle was the first who instituted exact experiments into the relation between colour and heat; and by this means not only ascertained some very important facts, but laid a foundation for that union between optics and thermotics, which, though not yet completed, now merely waits for some great philosopher to strike out a generalisation large enough to cover both, and thus fuse the two sciences into a single study. It is also to Boyle, more than to any other Englishman, that we owe the science of hydrostatics in the state in which we now possess it.* He is also the original discoverer of that beautiful law, so fertile in valuable results, according to which the elasticity of air varies as its density. And, in the opinion of one of the most eminent modern naturalists, it was Boyle who opened up those chemical inquiries which went on accumulating until, a century later, they supplied the means by which Lavoisier and his contemporaries fixed the real basis of chemistry, and enabled it for the first time to take its proper stand among those sciences that deal with the external world.—*Buckle's History of Civilization*, vol. i.

SIR ISAAC NEWTON'S ROOMS AND LABORATORY IN TRINITY COLLEGE, CAMBRIDGE.

Of the rooms occupied by Newton during his early residence at Cambridge, it is now difficult to settle the locality. The chamber allotted to him as Fellow, in 1667, was "the Spiritual Chamber," conjectured to have been the ground-room, next the chapel, but it is not certain that he resided there. The rooms in which he lived from 1682 till he left Cambridge, are in the north-east corner of the great court, on the first floor, on the right or north of the gateway or principal entrance to the college. His laboratory, as Dr. Humphrey Newton tell us, was "on the left end of the garden, near the east end of the chapel; and his telescope (refracting) was five feet long, and placed at the head of the stairs, going down into the garden."† The east side of Newton's rooms has been altered within the last fifty years: Professor Sedgwick, who came up to college in 1804, recollects a wooden room, supported on an arcade, shown in Loggan's view, in place of which arcade is now a wooden wall and brick chimney.

Dr. Humphrey Newton relates that in college Sir Isaac very rarely went to bed till two or three o'clock in the morning, sometimes not till five or six, especially at spring and fall of the leaf, when he used to employ about six weeks in his laboratory, the fire scarcely going out either night or day; he sitting up one night, and Humphrey another, till he had finished his chemical experiments. Dr. Newton describes the laboratory as "well furnished with chymical materials, as bodyes, receivers, heads, crucibles, &c., which was made very little use of, ye crucibles excepted, in which he fused his metals: he would sometimes, though very seldom, look into an old mouldy book, which lay in his laboratory; I think it was titled *Agricola de Metallis*, the transmuting of metals being his chief design, for which purpose antimony was a great ingredient." "His brick furnaces, *pro re nata,* he made and altered himself without troubling a bricklayer." "What observations he might make with his telescope, I know not, but several of his observations about comets and the planets may be found scattered here and there in a book intitled *The Elements of Astronomy,* by Dr. David Gregory."*

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* Dr. Whewell (*Bridgewater Treatise*, p. 266) well observes, that Boyle and Pascal are to hydrostatics what Galileo is to mechanics, and Copernicus, Kepler, and Newton are to astronomy.

† The Rev. Mr. Turnor recollects that Mr. Jones, the tutor, mentioned, in one of his lectures on optics, that the reflecting telescope belonging to Newton was then lodged in the observatory over the gateway; and Mr. Turnor thinks that he once saw it, with a finder affixed to it.

NEWTON'S "APPLE-TREE."

Curious and manifold as are the trees associated with the great names of their planters, or those who have sojourned in their shade, the Tree which, by the falling of its fruit, suggested to Newton the idea of Gravity, is of paramount interest. It appears that, in the autumn of 1665, Newton left his college at Cambridge for his paternal home at Woolsthorpe. "When sitting alone in the garden," says Sir David Brewster, "and speculating on the power of gravity, it occurred to him, that as the same power by which the apple fell to the ground was not sensibly diminished at the greatest distance from the centre of the earth to which we can reach, neither at the summits of the loftiest spires, nor on the tops of the highest mountains, it might extend to the moon and retain her in her orbit, in the same manner as it bends into a curve a stone or a cannon-ball when projected in a straight line from the surface of the earth."—*Life of Newton,* vol. i. p. 26. Sir David Brewster notes, that neither Pemberton nor Whiston, who received from Newton himself his first ideas of gravity, records this story of the falling apple. It was mentioned, however, to Voltaire by Catherine Barton, Newton's niece; and to Mr. Green by Martin Folkes, President of the Royal Society. Sir David Brewster saw the reputed apple-tree in 1814, and brought away a portion of one of its roots. The tree was so much decayed that it was cut down in 1820, and the wood of it carefully preserved by Mr. Turnor, of Stoke Rocheford.

* The story of the dog "Diamond" having caused the burning of certain papers is laid in London, and in Newton's later years. In the notes to Maude's *Wenleysdale,* a person then living (1780) relates, that Sir Isaac being called out of his study to a contiguous room, a little dog, called Diamond, the constant but incurious attendant of his master's researches, happened to be left among the papers, and by a fatality not to be retrieved, as it was in the latter part of Sir Isaac's days, threw down a lighted candle, which consumed the almost finished labour of some years. Sir Isaac returning too late but to behold the dreadful wreck, rebuked the author of it with an exclamation (*ad sidera palmas*), "O Diamond! Diamond! thou little knowest the mischief done!" without adding a single stripe. M. Biot gives this fiction as a true story, which happened some years after the publication of the *Principia;* and he characterises the accident as having deprived the sciences for ever of the fruit of so much of Newton's labours.—Brewster's *Life,* vol. ii. p. 139, note. Dr. Newton remarks, that Sir Isaac never had any communion with dogs or cats; and Sir David Brewster adds, that the view which M. Biot has taken of the idle story of the dog Diamond, charged with fire-raising among Newton's manuscripts, and of the influence of this accident upon the mind of their author, is utterly incomprehensible. The fiction, however, was turned to account in giving colour to M. Biot's misrepresentation.

De Morgan (in *Notes and Queries,* 2d series, No. 139, p. 169) questions whether the fruit was an apple, and maintains that the anecdote rests upon very slight authority; more especially as the idea had for many years been floating before the minds of physical inquirers; although Newton cleared away the confusions and difficulties which prevented very able men from proceeding beyond conjecture, and by this means established *universal* gravitation.

NEWTON'S "PRINCIPIA."

"It may be justly said," observes Halley, "that so many and so valuable philosophical truths as are herein discovered and put past dispute were never yet owing to the capacity and industry of any one man." "The importance and generality of the discoveries," says Laplace, "and the immense number of original and profound views, which have been the germ of the most brilliant theories of the philosophers of this (18th) century, and all presented with much elegance, will ensure to the work on the *Mathematical Principles of Natural Philosophy* a preëminence above all the other productions of human genius."

DESCARTES' LABOURS IN PHYSICS.

The most profound among the many eminent thinkers France has produced, is Réné Descartes, of whom the least that can be said is, that he effected a revolution more decisive than has ever been brought about by any other single mind; that he was the first who successfully applied algebra to geometry; that he pointed out the important law of the sines; that in an age in which optical instruments were extremely imperfect, he discovered the changes to which light is subjected in the eye by the crystalline lens; that he directed attention to the consequences resulting from the weight of the atmosphere; and that he moreover detected the causes of the rainbow. At the same time, and as if to combine the most varied forms of excellence, he is not only allowed to be the first geometrician of the age, but by the clearness and admirable precision of his style, he became one of the founders of French prose. And, although he was constantly engaged in those lofty inquiries into the nature of the human mind, which can never be studied without wonder, he combined with them a long course of laborious experiment upon the animal frame, which raised him to the highest rank among the anatomists of his time. The great discovery made by Harvey of the Circulation of the Blood was neglected by most of his contemporaries; but it was at once recognised by Descartes, who made it the basis of the physiological part of his work on man. He was likewise the discoverer of the lacteals by Aselli, which, like every great truth yet laid before the world, was at its first appearance, not only disbelieved, but covered with ridicule.—*Buckle's History of Civilization,* vol. i.

CONIC SECTIONS.

If a cone or sugar-loaf be cut through in certain directions, we shall obtain figures which are termed conic sections: thus, if we cut through a sugar-loaf parallel to its base or bottom, the outline or edge of the loaf where it is cut will be *a circle.* If the cut is made so as to slant, and not be parallel to the base of the loaf, the outline is an *ellipse,* provided the cut goes quite through the sides of the loaf all round; but if it goes slanting, and parallel to the line of the loaf's side, the outline is a *parabola,* a conic section or curve, which is distinguished by characteristic properties, every point of it bearing a certain fixed relation to a certain point within it, as the circle does to its centre. —*Dr. Paris's Notes to Philosophy in Sport, &c.*

POWER OF COMPUTATION.

The higher class of mathematicians, at the end of the seventeenth century, had become excellent computers, particularly in England, of which Wallis, Newton, Halley, the Gregorys, and De Moivre, are splendid examples. Before results of extreme exactness had become quite familiar, there was a gratifying sense of power in bringing out the new methods. Newton, in one of his letters to Oldenburg, says that he was at one time too much attached to such things, and that he should be ashamed to say to what number of figures he was in the habit of carrying his results. The growth of power of computation on the Continent did not, however, keep pace with that of the same in England. In 1696, De Laguy, a well-known writer on algebra, and a member of the Academy of Sciences, said that the most skilful computer could not, in less than a month, find within a unit the cube root of 696536483318640035073641037.—*De Morgan.*

"THE SCIENCE OF THE COSMOS."

Humboldt characterises this "uncommon but definite expression" as the treating of "the assemblage of all things with which space is filled, from the remotest nebulæ to the climatic distribution of those delicate tissues of vegetable matter which spread a variegated covering over the surface of our rocks." The word *cosmos,* which primitively, in the Homeric ages, indicated an idea of order and harmony, was subsequently adopted in scientific language, where it was gradually applied to the order observed in the movements of the heavenly bodies; to the whole universe; and then finally to the world in which this harmony was reflected to us.

Physical Phenomena.

ALL THE WORLD IN MOTION.

Humboldt, in his *Cosmos*,* gives the following beautiful illustrative proofs of this phenomenon:

> If, for a moment, we imagine the acuteness of our senses preternaturally heightened to the extreme limits of telescopic vision, and bring together events separated by wide intervals of time, the apparent repose which reigns in space will suddenly vanish; countless stars will be seen moving in groups in various directions; nebulæ wandering, condensing, and dissolving like cosmical clouds; the milky way breaking up in parts, and its veil rent asunder. In every point of the celestial vault we shall recognise the dominion of progressive movement, as on the surface of the earth where vegetation is constantly putting forth its leaves and buds, and unfolding its blossoms. The celebrated Spanish botanist, Cavanilles, first conceived the possibility of "seeing grass grow," by placing the horizontal micrometer wire of a telescope, with a high magnifying power, at one time on the point of a bamboo shoot, and at another on the rapidly unfolding flowering stem of an American aloe; precisely as the astronomer places the cross of wires on a culminating star. Throughout the whole life of physical nature—in the organic as in the sidereal world—existence, preservation, production, and development, are alike associated with motion as their essential condition.

THE AXIS OF ROTATION.

It is remarkable as a mechanical fact, that nothing is so permanent in nature as the Axis of Rotation of any thing which is rapidly whirled. We have examples of this in every-day practice. The first is the motion of *a boy's hoop*. What keeps the hoop from falling?—It is its rotation, which is one of the most complicated subjects in mechanics.

Another thing pertinent to this question is, *the motion of a quoit*. Every body who ever threw a quoit knows that to make it preserve its position as it goes through the air, it is necessary to give it a whirling motion. It will be seen that while whirling, it preserves its plane, whatever the position of the plane may be, and however it may be inclined to the direction in which the quoit travels. Now, this has greater analogy with the motion of the earth than any thing else.

Another illustration is *the motion of a spinning top*. The greatest mathematician of the last century, the celebrated Euler, has written a whole book on the motion of a top, and his Latin treatise *De motu Turbinis* is one of the most remarkable books on mechanics. The motion of a top is a matter of the greatest importance; it is applicable to the elucidation of some of the greatest phenomena of nature. In all these instances there is this wonderful tendency in rotation to preserve the axis of rotation unaltered.—*Prof. Airy's Lect. on Astronomy.*

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* **Bohn's editi**

THE EARTH'S ANNUAL MOTION.

In conformity with the Copernican view of our system, we must learn to look upon the sun as the comparatively motionless centre about which the earth performs an annual elliptic orbit of the dimensions and excentricity, and with a velocity, regulated according to a certain assigned law; the sun occupying one of the foci of the ellipse, and from that station quietly disseminating on all sides its light and heat; while the earth travelling round it, and presenting itself differently to it at different times of the year and day, passes through the varieties of day and night, summer and winter, which we enjoy.—*Sir John Herschel's Outlines of Astronomy.*

Laplace has shown that the length of the day has not varied the hundredth part of a second since the observations of Hipparchus, 2000 years ago.

STABILITY OF THE OCEAN.

In submitting this question to analysis, Laplace found that the *equilibrium of the ocean is stable if its density is less than the mean density of the earth*, and that its equilibrium cannot be subverted unless these two densities are equal, or that of the earth less than that of its waters. The experiments on the attraction of Schehallien and Mont Cenis, and those made by Cavendish, Reich, and Baily, with balls of lead, demonstrate that the mean density of the earth is at least *five* times that of water, and hence the stability of the ocean is placed beyond a doubt. As the seas, therefore, have at one time covered continents which are now raised above their level, we must seek for some other cause of it than any want of stability in the equilibrium of the ocean. How beautifully does this conclusion illustrate the language of Scripture, "Hitherto shalt thou come, but no further"! (*Job* xxxviii. 11.)

COMPRESSION OF BODIES.

Sir John Leslie observes, that *air compressed* into the fiftieth part of its volume has its elasticity fifty times augmented: if it continued to contract at that rate, it would, from its own incumbent weight, acquire the density of water at the depth of thirty-four miles. But water itself would have its density doubled at the depth of ninety-three miles, and would attain the density of quicksilver at the depth of 362 miles. In descending, therefore, towards the centre, through nearly 4000 miles, the condensation of ordinary substances would surpass the utmost powers of conception. Dr. Young says, that steel would be compressed into one-fourth, and stone into one-eighth, of its bulk at the earth's centre.—*Mrs. Somerville.*

THE WORLD IN A NUTSHELL.

From the many proofs of the non-contact of the atoms, even in the most solid parts of bodies; from the very great space obviously occupied by pores—the mass having often no more solidity than a heap of empty boxes, of which the apparently solid parts may still be as porous in a second degree and so on; and from the great readiness with which light passes in all directions through dense bodies, like glass, rock-crystal, diamond, &c., it has been argued that there is so exceedingly little of really solid matter even in the densest mass, that *the whole world*, if the atoms could be brought into absolute contact, *might be compressed into a nutshell.* We have as yet no means of determining exactly what relation this idea has to truth.—*Arnott.*

THE WORLD OF ATOMS.

The infinite groups of atoms flying through all time and space, in different directions and under different laws, have interchangeably tried and exhibited every possible mode of rencounter: sometimes repelled from each other by concussion; and sometimes adhering to each other from their own jagged or pointed construction, or from the casual interstices which two or more connected atoms must produce, and which may be just adapted to those of other figures,—as globular, oval, or square. Hence the origin of compound and visible bodies; hence the origin of large masses of matter; hence, eventually, the origin of the world.—*Dr. Good's Book of Nature.*

The great Epicurus speculated on "the plastic nature" of atoms, and attributed to this *nature* the power they possess of arranging themselves into symmetric forms. Modern philosophers satisfy themselves with attraction; and reasoning from analogy, imagine that each atom has a polar system.—*Hunt's Poetry of Science.*

MINUTE ATOMS OF THE ELEMENTS: DIVISIBILITY OF MATTER.

So minute are the parts of the elementary bodies in their ultimate state of division, in which condition they are usually termed *atoms*, as to elude all our powers of inspection, even when aided by the most powerful microscopes. Who can see the particles of gold in a solution of that metal in *aqua regia*, or those of common salt when dissolved in water? Dr. Thomas Thomson has estimated the bulk of an ultimate particle or atom of lead as less than $\frac{1}{888492000000000}$th of a cubic inch, and concludes that its weight cannot exceed the $\frac{1}{310000000000}$th of a grain.

This curious calculation was made by Dr. Thomson, in order to show to what degree Matter could be divided, and still be sensible to the eye. He dissolved a grain of nitrate of lead in 500,000 grains of water, and passed through the solution a current of sulphuretted hydrogen; when the whole liquid became sensibly discoloured. Now, a grain of water may be regarded as being almost equal to a drop of that liquid, and a drop may be easily spread out so as to cover a square inch of surface. But under an ordinary microscope the millionth of a square inch may be distinguished by the eye. The water, therefore, could be divided into 500,000,000,000 parts. But the lead in a grain of nitrate of lead weighs 0·62 of a grain; an atom of lead, accordingly, cannot weigh more than $\frac{1}{310000000000}$th of a grain; while the atom of sulphur, which in combination with the lead rendered it visible, could not weigh more than $\frac{1}{2015000000000}$, that is, the two-billionth part of a grain.—*Professor Low; Jameson's Journal*, No. 106.

WEIGHT OF AIR.

Air can be so rarefied that the contents of a cubic foot shall not weigh the tenth part of a grain: if a quantity that would fill a space the hundredth part of an inch in diameter be separated from the rest, the air will still be found there, and we may reasonably conceive that there may be several particles present, though the weight is less than the seventeen-hundred-millionth of a grain.

DURATION OF THE PYRAMID.

The great reason of the duration of the pyramid above all other forms is, that it is most fitted to resist the force of gravitation. Thus the Pyramids of Egypt are the oldest monuments in the world.

INERTIA ILLUSTRATED.

Many things of common occurrence (says Professor Tyndall) are to be explained by reference to the quality of inactivity. We will here state a few of them.

When a railway train is moving, if it strike against any obstacle which arrests its motion, the passengers are thrown forward in the direction in which the train was proceeding. Such accidents often occur on a small scale, in attaching carriages at railway stations. The reason is, that the passengers share the motion of the train, and, as matter, they tend to persist in motion. When the train is suddenly checked, this tendency exhibits itself by the falling forward referred to. In like manner, when a train previously at rest is suddenly set in motion, the tendency of the passengers to remain at rest evinces itself by their falling in a direction opposed to that in which the train moves.

THE LEANING TOWER OF PISA.*

Sir John Leslie used to attribute the stability of this tower to the cohesion of the mortar it is built with being sufficient to maintain it erect, in spite of its being out of the condition required by physics—to wit, that "in order that a column shall stand, a perpendicular let fall from the centre of gravity must fall within the base." Sir John describes the Tower of Pisa to be in violation of this principle ; but, according to later authorities, the perpendicular falls within the base.

EARLY PRESENTIMENTS OF CENTRIFUGAL FORCES.

Jacobi, in his researches on the mathematical knowledge of the Greeks, comments on "the profound consideration of nature evinced by Anaxagoras, in whom we read with astonishment a passage asserting that the moon, if the centrifugal force were intermitted, would fall to the earth like a stone from a sling." Anaxagoras likewise applied the same theory of "falling where the force of rotation had been intermitted" to all the material celestial bodies. In Aristotle and Simplicius may also be traced the idea of "the non-falling of heavenly bodies when the rotatory force predominates over the actual falling force, or downward attraction ;" and Simplicius mentions that "water in a phial is not spilt when the movement of rotation is more rapid than the downward movement of the water." This is illustrated at the present day by rapidly whirling a pail half-filled with water without spilling a drop.

Plato had a clearer idea than Aristotle of the *attractive force* exercised by the earth's centre on all heavy bodies removed from it; for he was acquainted with the acceleration of falling bodies, although he did not correctly understand the cause. John Philoponus, the Alexandrian, probably in the sixth century, was the first who ascribed the movement of the heavenly bodies to a primitive impulse, connecting with this idea that of the fall of bodies, or the tendency of all substances, whether heavy or light, to reach the ground. The idea conceived by Copernicus, and more clearly expressed by Kepler, who even applied it to the ebb and flow of the ocean, received in 1666 and 1674 a new impulse from Robert Hooke; and next Newton's theory of gravitation presented the grand means of converting the whole of physical astronomy into a true *mechanism of the heavens.*

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* When at Pisa, many years since, Captain Basil Hall investigated the origin and divergence of the tower from the perpendicular, and established completely to his own satisfaction that it had been built from top to bottom originally just as it now stands. His reasons for thinking so were, that the line of the tower, on that side towards which it leans, has not the same curvature as the line on the opposite, or what may be called the upper side. If the tower had been built upright, and then been made to incline over, the line of the wall on that side towards which the inclination was given would be more or less concave in that direction, owing to the nodding or "swagging over" of the top, by the simple action of gravity acting on a very tall mass of masonry, which is more or less elastic when placed in a sloping position. But the contrary is the fact; for the line of wall on the side towards which the tower leans is decidedly more convex than the opposite side. Captain Hall had therefore no doubt whatever that the architect, in rearing his successive courses of stones, gained or stole a little at each layer, so as to render his work less and less overhanging as he went up; and thus, without betraying what he was about, really gained stability.—See *Patchwork.*

The law of gravitation knows no exception; it accounts accurately for the most complex motions of the members of our own system; nay more, the paths of double stars, far removed from all appreciable effects of our portion of the universe, are in perfect accordance with its theory.*

HEIGHT OF FALLS.

The fancy of the Greeks delighted itself in wild visions of the height of falls. In Hesiod's *Theogony* it is said, speaking of the fall of the Titans into Tartarus, "if a brazen anvil were to fall from heaven nine days and nine nights long, it would reach the earth on the tenth." This descent of the anvil in 777,600 seconds of time gives an equivalent in distance of 309,424 geographical miles (allowance being made, according to Galle's calculation, for the considerable diminution in force of attraction at planetary distances); therefore 1½ times the distance of the moon from the earth. But, according to the *Iliad*, Hephæstus fell down to Lemnos in one day; "when but a little breath was still in him."—*Note to Humboldt's Cosmos,* vol. iii.

RATE OF THE FALL OF BODIES.

A body falls in gravity precisely $16\frac{1}{16}$ feet in a second, and the velocity increases according to the squares of the time, viz.:

In ¼ (quarter of a second) a body falls	1 foot.
½ (half a second)	4 feet.
1 second	16 ,,
2 ditto	64 ,,
3 ditto	144 ,,

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* Lord Bacon proposed that, in order to determine whether the gravity of the earth arises from the gravity of its parts, a clock-pendulum should be swung in a mine, as was recently done at Harton colliery by the Astronomer Royal.

When, in 1812, Ampère noted the phenomena of the pendulum, and showed that its movement was produced only when the eye of the observer was fixed on the instrument, and endeavoured to prove thereby that the motion was due to a play of the muscles, some members of the French Academy objected to the consideration of a subject connected to such an extent with superstition.

The power of gravity at two miles distance from the earth is four times less than at one mile; at three miles nine times less, and so on. It goes on lessening, but is never destroyed. —*Notes in various Sciences.*

VARIETIES OF SPEED.

A French scientific work states the ordinary rate to be:

	per second.
Of a man walking	4 feet.
Of a good horse in harness	12 ,,
Of a rein-deer in a sledge on the ice	26 ,,
Of an English race-horse	43 ,,
Of a hare	88 ,,
Of a good sailing ship	19 ,,
Of the wind	82 ,,
Of sound	1038 ,,
Of a 24-pounder cannon-ball	1300 ,,

LIFTING HEAVY PERSONS.

One of the most extraordinary pages in Sir David Brewster's *Letters on Natural Magic* is the experiment in which a heavy man is raised with the greatest facility when he is lifted up the instant that his own lungs, and those of the persons who raise him, are inflated with air. Thus the heaviest person in the party lies down upon two chairs, his legs being supported by the one and his back by the other. Four persons, one at each leg, and one at each shoulder, then try to raise him—the person to be raised giving two signals, by clapping his hands. At the first signal, he himself and the four lifters begin to draw a long and full breath; and when the inhalation is completed, or the lungs filled, the second signal is given for raising the person from the chair. To his own surprise, and that of his bearers, he rises with the greatest facility, as if he were no heavier than a feather. Sir David Brewster states that he has seen this inexplicable experiment performed more than once; and he appealed for testimony to Sir Walter Scott, who had repeatedly seen the experiment, and performed the part both of the load and of the bearer. It was first shown in England by Major H., who saw it performed in a large party at Venice, under the direction of an officer of the American navy.*

Sir David Brewster (in a letter to *Notes and Queries*, No. 143) further remarks, that "the inhalation of the lifters the moment the effort is made is doubtless essential, and for this reason: when we make a great effort, either in pulling or lifting, we always fill the chest with air previous to the effort; and when the inhalation is completed, we close the *rima glottidis* to keep the air in the lungs. The chest being thus kept expanded, the pulling or lifting muscles have received as it were a fulcrum round which their power is exerted; and we can thus lift the greatest weight which the muscles are capable of doing. When the chest collapses by the escape of the air, the lifters lose their muscular power; reinhalation of air by the liftee can certainly add nothing to the power of the lifters, or diminish his own weight, which is only increased by the weight of the air which he inhales."

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* This curious feat was first recorded by Pepys, in his *Diary*, under the date 31st of July 1665.

"FORCE CAN NEITHER BE CREATED NOR DESTROYED."

Professor Faraday, in his able inquiry upon "the Conservation of Force," maintains that to admit that force may be destructible, or can altogether disappear, would be to admit that matter could be uncreated; for we know matter only by its forces. From his many illustrations we select the following:

> The indestructibility of individual matter is a most important case of the Conservation of Chemical Force. A molecule has been endowed with powers which give rise in it to various qualities; and those never change, either in their nature or amount. A particle of oxygen is ever a particle of oxygen; nothing can in the least wear it. If it enters into combination, and disappears as oxygen; if it pass through a thousand combinations—animal, vegetable, mineral; if it lie hid for a thousand years, and then be evolved,—it is oxygen with the first qualities, neither more nor less. It has all its original force, and only that; the amount of force which it disengaged when hiding itself, has again to be employed in a reverse direction when it is set at liberty: and if, hereafter, we should decompose oxygen, and find it compounded of other particles, we should only increase the strength of the proof of the conservation of force; for we should have a right to say of these particles, long as they have been hidden, all that we could say of the oxygen itself.

In conclusion, he adds:

> Let us not admit the destruction or creation of force without clear and constant proof. Just as the chemist owes all the perfection of his science to his dependence on the certainty of gravitation applied by the balance, so may the physical philosopher expect to find the greatest security and the utmost aid in the principle of the conservation of force. All that we have that is good and safe—as the steam-engine, the electric telegraph, &c.—witness to that principle; it would require a perpetual motion, a fire without heat, heat without a source, action without reaction, cause without effect, or effect without cause, to displace it from its rank as a law of nature.

NOTHING LOST IN THE MATERIAL WORLD.

"It is remarkable," says Kobell in his *Mineral Kingdom*, "how a change of place, a circulation as it were, is appointed for the inanimate or naturally immovable things upon the earth; and how new conditions, new creations, are continually developing themselves in this way. I will not enter here into the evaporation of water, for instance from the widely-spreading ocean; how the clouds produced by this pass over into foreign lands and then fall again to the earth as rain, and how this wandering water is, partly at least, carried along new journeys, returning after various voyages to its original home: the mere mechanical phenomena, such as the transfer of seeds by the winds or by birds, or the decomposition of the surface of the earth by the friction of the elements, suffice to illustrate this."

TIME AN ELEMENT OF FORCE.

Professor Faraday observes that Time is growing up daily into importance as an element in the exercise of Force, which he thus strikingly illustrates:

The earth moves in its orbit of time; the crust of the earth moves in time; light moves in time; an electro-magnet requires time for its charge by an electric current: to inquire, therefore, whether power, acting either at sensible or insensible distances, always acts in *time*, is not to be metaphysical; if it acts in time and across space, it must act by physical lines of force; and our view of the nature of force may be affected to the extremest degree by the conclusions which experiment and observation on time may supply, being perhaps finally determinable only by them. To inquire after the possible time in which gravitating, magnetic, or electric force is exerted, is no more metaphysical than to mark the times of the hands of a clock in their progress; or that of the temple of Serapis, and its ascents and descents; or the periods of the occultation of Jupiter's satellites; or that in which the light comes from them to the earth. Again, in some of the known cases of the action of time something happens while *the time* is passing which did not happen before, and does not continue after; it is therefore not metaphysical to expect an effect in *every* case, or to endeavour to discover its existence and determine its nature.

CALCULATION OF HEIGHTS AND DISTANCES.

By the assistance of a seconds watch the following interesting calculations may be made:

If a traveller, when on a precipice or on the top of a building, wish to ascertain the height, he should drop a stone, or any other substance sufficiently heavy not to be impeded by the resistance of the atmosphere; and the number of seconds which elapse before it reaches the bottom, carefully noted on a seconds watch, will give the height. For the stone will fall through the space of $16\frac{1}{8}$ feet during the first second, and will increase in rapidity as the square of the time employed in the fall: if, therefore, $16\frac{1}{8}$ be multiplied by the number of seconds the stone has taken to fall, this product also multiplied by the same number of seconds will give the height. Suppose the stone takes five seconds to reach the bottom:

$16\frac{1}{8}\times5=80\frac{5}{8}\times5=403\frac{1}{8}$, height of the precipice.

The Count Xavier de Maistre, in his *Expédition nocturne autour de ma Chambre*, anxious to ascertain the exact height of his room from the ground on which Turin is built, tells us he proceeded as follows: "My heart beat quickly, and I just counted three pulsations from the instant

I dropped my slipper until I heard the sound as it fell in the street, which, according to the calculations made of the time taken by bodies in their accelerated fall, and of that employed by the sonorous undulations of the air to arrive from the street to my ear, gave the height of my apartment as 94 feet 3 inches 1 tenth (French measure), supposing that my heart, agitated as it was, beat 120 times in a minute."

A person travelling may ascertain his rate of walking by the aid of a slight string with a piece of lead at one end, and the use of a seconds watch ; the string being knotted at distances of 44 feet, the 120th part of an English mile, and bearing the same proportion to a mile that half a minute bears to an hour. If the traveller, when going at his usual rate, drops the lead, and suffers the string to slip through his hand, the number of knots which pass in half a minute indicate the number of miles he walks in an hour. This contrivance is similar to a *log-line* for ascertaining a ship's rate at sea: the lead is enclosed in wood (whence the name *log*), that it may float, and the divisions, which are called *knots,* are measured for nautical miles. Thus, if ten knots are passed in half a minute, they show that the vessel is sailing at the rate of ten knots, or miles, an hour: a seconds watch would here be of great service, but the half-minute sand-glass is in general use.

The rapidity of a river may be ascertained by throwing-in a light floating substance, which, if not agitated by the wind, will move with the same celerity as the water: the distance it floats in a certain number of seconds will give the rapidity of the stream ; and this indicates the height of its source, the nature of its bottom, &c.—See *Sir Howard Douglas on Bridges. Thomson's Time and Time-keepers.*

SAND IN THE HOUR-GLASS.

It is a noteworthy fact, that the flow of Sand in the Hour-glass is perfectly equable, whatever may be the quantity in the glass; that is, the sand runs no faster when the upper half of the glass is quite full than when it is nearly empty. It would, however, be natural enough to conclude, that when full of sand it would be more swiftly urged through the aperture than when the glass was only a quarter full, and near the close of the hour.

The fact of the even flow of sand may be proved by a very simple experiment. Provide some silver sand, dry it over or before the fire, and pass it through a tolerably fine sieve. Then take a tube, of any length or diameter, closed at one end, in which make a small hole, say the eighth of an inch; stop this with a peg, and fill up the tube with the sifted sand. Hold the tube steadily, or fix it to a wall or frame at any height from a table; remove the peg, and permit the sand to flow in any measure for any given time, and note the quantity. Then let the tube be emptied, and only half or a quarter filled with sand; measure again for a like time, and the same quantity of sand will flow: even if you press the sand in the tube with a ruler or stick, the flow of the sand through the hole will not be increased.

The above is explained by the fact, that when the sand is poured into the tube, it fills it with a succession of conical heaps; and that all the weight which the bottom of the tube sustains is only that of the heap which *first* falls upon it, as the succeeding heaps do not press downward, but only against the sides or walls of the tube.

FIGURE OF THE EARTH.

By means of a purely astronomical determination, based upon the action which the earth exerts on the motion of the moon, or, in other words, on the inequalities in lunar longitudes and latitudes, Laplace has shown in one single result the mean Figure of the Earth.

It is very remarkable that an astronomer, without leaving his observatory, may, merely by comparing his observations with mean analytical results, not only be enabled to determine with exactness the size and degree of ellipticity of the earth, but also its distance from the sun and moon; results that otherwise could only be arrived at by long and arduous expeditions to the most remote parts of both hemispheres. The moon may therefore, by the observation of its movements, render appreciable to the higher departments of astronomy the ellipticity of the earth, as it taught the early astronomers the rotundity of our earth by means of its eclipses.—*Laplace's Expos. du Syst. du Monde.*

HOW TO ASCERTAIN THE EARTH'S MAGNITUDE.

Sir John Herschel gives the following means of approximation. It appears by observation that two points, each ten feet above the surface, cease to be visible from each other over still water, and, in average atmospheric circumstances, at a distance of about eight miles. But 10 feet is the 528th part of a mile; so that half their distance, or four miles, is to the height of each as 4 × 528, or 2112:1, and therefore in the same proportion to four miles is the length of the earth's diameter. It must, therefore, be equal to $4 \times 2112 = 8448$, or in round numbers, about 8000 miles, which is not very far from the truth.

The excess is, however, about 100 miles, or $\frac{1}{80}$th part. As convenient numbers to remember, the reader may bear in mind, that in our latitude there are just as many thousands of feet in a degree of the meridian as there are days in the year (365); that, speaking loosely, a degree is about seventy British statute miles, and a second about 100 feet; that the equatorial circumference of the earth is a little less than 25,000 miles (24,899), and the ellipticity or polar flattening amounts to $\frac{1}{300}$th part of the diameter.—*Outlines of Astronomy.*

MASS AND DENSITY OF THE EARTH.

With regard to the determination of the Mass and Density of the Earth by direct experiment, we have, in addition to the deviations of the pendulum produced by mountain masses, the variation of the same instruments when placed in a mine 1200 feet in depth. The most recent experiments were conducted by Professor Airy, in the Harton coal-pit, near South Shields:* the oscillations of the pendulum at the bottom of the pit were compared with those of a clock above; the beats of the clock were transferred below for comparison by an electric wire; and it was thus determined that a pendulum vibrating seconds at the mouth of the pit would gain 2¼ seconds per day at its bottom. The final result of the calculations depending on this experiment, which were published in the *Philosophical Transactions* of 1856, gives 6·565 for the mean density of the earth. The celebrated Cavendish experiment, by means of which the density of the earth was determined by observing the attraction of leaden balls on each other, has been repeated in a manner exhibiting an astonishing amount of skill and patience by the late Mr. F. Baily.† The result of these experiments, combined with those previously made, gives as a mean result 5·441 as the earth's density, when compared with water; thus confirming one of Newton's astonishing divinations, that the mean density of the earth would be found to be between five and six times that of water.

Humboldt is, however, of opinion that "we know only the mass of the whole earth and its mean density by comparing it with the open strata, which alone are accessible to us. In the interior of the earth, where all knowledge of its chemical and mineralogical character fails, we are limited to as pure conjecture as in the remotest bodies that revolve round the sun. We can determine nothing with certainty regarding the depth at which the geological strata must be supposed to be in a state of softening or of liquid fusion, of the condition of fluids when heated under an enormous pressure, or of the law of the increase of density from the upper surface to the centre of the earth."—*Cosmos*, vol. i.

In M. Foucault's beautiful experiment, by means of the vibration of a long pendulum, consisting of a heavy mass of metal suspended by a long wire from a strong fixed support, is demonstrated to the eye the rotation of the earth. The Gyroscope of the same philosopher is regarded not as a mere philosophical toy; but the principles of dynamics, by means of which it is made to demonstrate the earth's rotation on its own axis, are explained with the greatest clearness. Thus the ingenuity of M. Foucault, combined with a profound knowledge of mechanics, has obtained proofs of one of the most interesting problems of astronomy from an unsuspected source.

THE EARTH AND MAN COMPARED.

The Earth—speaking roundly—is 8000 miles in diameter;

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* The result of these experiments for ascertaining the variation of the gravity at great depths, has proved beyond doubt that the attraction of gravitation is increased at the depth of 1250 feet by $\frac{1}{19000}$ part.

† See the account of Mr. Baily's researches (with two illustrations) in *Things not generally Known*, p. vii., and "Weight of the Earth," p. 16.

the atmosphere is calculated to be fifty miles in altitude; the loftiest mountain peak is estimated at five miles above the level of the sea, for this height has never been visited by man; the deepest mine that he has formed is 1650 feet; and his own stature does not average six feet. Therefore, if it were possible for him to construct a globe 800 feet—or twice the height of St. Paul's Cathedral—in diameter, and to place upon any one point of its surface an atom of $\frac{1}{4380}$th of an inch in diameter, and $\frac{1}{720}$th of an inch in height, it would correctly denote the proportion that man bears to the earth upon which he moves.

When by measurements, in which the evidence of the method advances equally with the precision of the results, the volume of the earth is reduced to the millionth part of the volume of the sun; when the sun himself, transported to the region of the stars, takes up a very modest place among the thousands of millions of those bodies that the telescope has revealed to us; when the 38,000,000 of leagues which separate the earth from the sun have become, by reason of their comparative smallness, a base totally insufficient for ascertaining the dimensions of the visible universe; when even the swiftness of the luminous rays (77,000 leagues per second) barely suffices for the common valuations of science; when, in short, by a chain of irresistible proofs, certain stars have retired to distances that light could not traverse in less than a million of years;—we feel as if annihilated by such immensities. In assigning to man and to the planet that he inhabits so small a position in the material world, astronomy seems really to have made progress only to humble us.—*Arago.*

MEAN TEMPERATURE OF THE EARTH'S SURFACE.

Professor Dove has shown, by taking at all seasons the mean of the temperature of points diametrically opposite to each other, that the mean temperature *of the whole earth's surface* in June considerably exceeds that in December. This result, which is at variance with the greater proximity of the sun in December, is, however, due to a totally different and very powerful cause,—the greater amount of land in that hemisphere which has its summer solstice in June (*i. e.* the northern); and the fact is so explained by him. The effect of land under sunshine is to throw heat into the general atmosphere, and to distribute it by the carrying power of the latter over the whole earth. Water is much less effective in this respect, the heat penetrating its depths and being there absorbed; so that the surface never acquires a very elevated temperature, even under the equator.—*Sir John Herschel's Outlines.*

TEMPERATURE OF THE EARTH STATIONARY.

Although, according to Bessel, 25,000 cubic miles of water flow in every six hours from one quarter of the earth to another, and the temperature is augmented by the ebb and flow of every tide, all that we know with certainty is, that the *resultant effect* of all the thermal agencies to which the earth is exposed has undergone no perceptible change within the historic period. We owe this fine deduction to Arago. In order that the *date palm* should ripen its fruit, the mean temperature of the place must exceed 70 deg. Fahr.; and, on the other hand, the *vine* cannot be cultivated successfully when the temperature is 72 deg. or upwards. Hence the mean temperature of any place at which these two plants flourished and bore fruit must lie between these narrow limits, *i. e.* could not differ from 71 deg. Fahr. by more than a single degree. Now from the Bible we learn that both plants were *simultaneously* cultivated in the central valleys of Palestine in the time of Moses; and its then temperature is thus definitively determined. It is the same at the present time; so that the mean temperature of this portion of the globe has not sensibly altered in the course of thirty-three centuries.

THEORY OF CRYSTALLISATION.

Professor Plücker has ascertained that certain crystals, in particular the cyanite, "point very well to the north by the magnetic power of the earth only. It is a true compass-needle; and more than that, you may obtain its declination." Upon this Mr. Hunt remarks: "We must remember that this crystal, the cyanite, is a compound of silica and alumina only. This is the amount of experimental evidence which science has afforded in explanation of the conditions under which nature pursues her wondrous work of crystal formation. We see just sufficient of the operation to be convinced that the luminous star which shines in the brightness of heaven, and the cavern-secreted gem, are equally the result of forces which are known to us in only a few of their modifications."—*Poetry of Science.*

Gay Lussac first made the remark, that a crystal of potash-alum, transferred to a solution of ammonia-alum, continued to increase without its form being modified, and might thus be covered with alternate layers of the two alums, preserving its regularity and proper crystalline figure. M. Beudant afterwards observed that other bodies, such as the sulphates of iron and copper, might present themselves in crystals of the same form and angles, although the form was not a simple one, like that of alum. But M. Mitscherlich first recognised this correspondence in a sufficient number of cases to prove that it was a general consequence of similarity of composition in different bodies.—*Graham's Elements of Chemistry.*

IMMENSE CRYSTALS.

Crystals are found in the most microscopic character, and of an exceedingly large size. A crystal of quartz at Milan is three feet and a quarter long, and five feet and a half in circumference: its weight is 870 pounds. Beryls have been found in New Hampshire measuring four feet in length.—*Dana.*

VISIBLE CRYSTALLISATION.

Professor Tyndall, in a lecture delivered by him at the Royal Institution, London, on the properties of Ice, gave the following interesting illustration of crystalline force. By perfectly cleaning a piece of glass, and placing on it a film of a solution of chloride of ammonium or sal ammoniac, the action of crystallisation was shown to the whole audience. The glass slide was placed in a microscope, and the electric light passing through it was concentrated on a white disc. The image of the crystals, as they started into existence, and shot across the disc in exquisite arborescent and symmetrical forms, excited the admiration of every one. The lecturer explained that the heat, causing the film of moisture to evaporate, brought the particles of salt sufficiently near to exercise the crystalline force, the result being the beautiful structure built up with such marvellous rapidity.

UNION OF MINERALOGY AND GEOMETRY.

It is a peculiar characteristic of minerals, that while plants and animals differ in various regions of the earth, mineral matter of the same character may be discovered in any part of the world, —at the Equator or towards the Poles; at the summit of the loftiest mountains, and in works far beneath the level of the sea. The granite of Australia does not necessarily differ from that of the British islands; and ores of the same metals (the proper geological conditions prevailing) may be found of the same general character in all regions. Climate and geographical position have no influence on the composition of mineral substances.

This uniformity may, in some measure, have induced philosophers to seek its extension to the forms of crystallography. About 1760 (says Mr. Buckle, in his *History of Civilization*), Romé de Lisle set the first example of studying crystals, according to a scheme so large as to include all the varieties of their primary forms, and to account for their irregularities and the apparent caprice with which they were arranged. In this investigation he was guided by the fundamental assumption, that what is called an irregularity is in truth perfectly regular, and that the operations of nature are invariable. Haüy applied this great idea to the almost innumerable forms in which minerals crystallise. He thus achieved a complete union between mineralogy and geometry; and, bringing the laws of space to bear on the molecular arrangements of matter, he was able to penetrate into the intimate structure of crystals. By this means he proved that the secondary forms of all crystals are derived from their primary forms by a regular process of decrement; and that when a substance is passing from a liquid to a solid state, its particles cohere, according to a scheme which provides for every possible change, since it includes even those subsequent layers which alter the ordinary type of the crystal, by disturbing its natural symmetry. To ascertain that such violations of symmetry are susceptible of mathematical calculation, was to make a vast addition to our knowledge; and, by proving that even the most uncouth and singular forms are the natural results of their antecedents, Haüy laid the foundation of what may be called the pathology of the inorganic world. However paradoxical such a notion may appear, it is certain that symmetry is to crystals what health is to animals; so that an irregularity of shape in the first corresponds with an appearance of disease in the second.—See *Hist. Civilization*, vol. i.

REPRODUCTIVE CRYSTALLISATION.

The general belief that only organic beings have the power of reproducing lost parts has been disproved by the experiments of Jordan on crystals. An octohedral crystal of alum was fractured; it was then replaced in a solution, and after a few days its injury was seen to be repaired. The whole crystal had of course increased in size; but the increase on the broken surface had been so much greater that a perfect octohedral form was regained.—*G. H. Lewes.*

This remarkable power possessed by crystals, in common with animals, of repairing their own injuries had, however, been thus previously referred to by Paget, in his *Pathology*, confirming the experiments of Jordan on this curious subject: "The ability to repair the damages sustained by injury . . . is not an exclusive property of living beings; for even crystals will repair themselves when, after pieces have been broken from them, they are placed in the same conditions in which they were first formed."

GLASS BROKEN BY SAND.

In some glass-houses the workmen show glass which has been cooled in the open air; on this they let fall leaden bullets without breaking the glass. They afterwards desire you to let a few grains of sand fall upon the glass, by which it is broken into a thousand pieces. The reason of this is, that the lead does not scratch the surface of the glass; whereas the sand, being sharp and angular, scratches it sufficiently to produce the above effect.

Sound and Light.

SOUNDING SAND.

Mr. Hugh Miller, the geologist, when in the island of Eigg, in the Hebrides, observed that a musical sound was produced when he walked over the white dry sand of the beach. At each step the sand was driven from his footprint, and the noise was simultaneous with the scattering of the sand; the cause being either the accumulated vibrations of the air when struck by the driven sand, or the accumulated sounds occasioned by the mutual impact of the particles of sand against each other. If a musket-ball passing through the air emits a whistling note, each individual particle of sand must do the same, however faint be the note which it yields; and the accumulation of these infinitesimal vibrations must constitute an audible sound, varying with the number and velocity of the moving particles. In like manner, if two plates of silex or quartz, which are but crystals of sand, give out a musical sound when mutually struck, the impact or collision of two minute crystals or particles of sand must do the same, in however inferior a degree; and the union of all these sounds, though singly imperceptible, may constitute the musical notes of "the Mountain of the Bell" in Arabia Petræa, or the lesser sounds of the trodden sea-beach of Eigg.—*North-British Review*, No. 5.

INTENSITY OF SOUND IN RAREFIED AIR.

The experiences during ascents of the highest mountains are contradictory. Saussure describes the sounds on the top of Mont Blanc as remarkably weak: a pistol-shot made no more noise than an ordinary Chinese cracker, and the popping of a bottle of champagne was scarcely audible. Yet Martius, in the same situation, was able to distinguish the voices of the guides at a distance of 1340 feet, and to hear the tapping of a lead pencil upon a metallic surface at a distance of from 75 to 100 feet.

MM. Wertheim and Breguet have propagated sound over the wire of an electric telegraph at the rate of 11,454 feet per second.

DISTANCE AT WHICH THE HUMAN VOICE MAY BE HEARD.

Experience shows that the human voice, under favourable circumstances, is capable of filling a larger space than was ever probably enclosed within the walls of a single room. Lieutenant Foster, on Parry's third Arctic expedition, found that he could converse with a man across the harbour of Port Bowen, a distance of 6696 feet, or about one mile and a quarter. Dr. Young records that at Gibraltar the human voice has been heard at a distance of ten miles. If sound be prevented from spreading and losing itself in the air, either by a pipe or an extensive flat surface, as a wall or still water, it may be conveyed to a great distance. Biot heard a flute clearly through a tube of cast-iron (the water-pipes of Paris) 3120 feet long: the lowest whisper was distinctly heard; indeed, the only way not to be heard was not to speak at all.

THE ROAR OF NIAGARA.

The very nature of the sound of running water pronounces its origin to be the bursting of bubbles: the impact of water against water is a comparatively subordinate cause, and could never of itself occasion the murmur of a brook; whereas, in streams which Dr. Tyndall has examined, he, in all cases where a ripple was heard, discovered bubbles caused by the broken column of water. Now, were Niagara continuous, and without lateral vibration, it would be as silent as a cataract of ice. In all probability, it has its "contracted sections," after passing which it is broken into detached masses, which, plunging successively upon the air-bladders formed by their precursors, suddenly liberate their contents, and thus create *the thunder of the waterfall.*

FIGURES PRODUCED BY SOUND.

Stretch a sheet of wet paper over the mouth of a glass tumbler which has a footstalk, and glue or paste the paper at the edges. When the paper is dry, strew dry sand thinly upon its surface. Place the tumbler on a table, and hold immediately above it, and parallel to the paper, a plate of glass, which you also strew with sand, having previously rubbed the edges smooth with emery powder. Draw a violin-bow along any part of the edges; and as the sand upon the glass is made to vibrate, it will form various figures, which will be accurately imitated by the sand upon the paper; or if a violin or flute be played within a few inches of the paper, they will cause the sand upon its surface to form regular lines and figures.

THE TUNING-FORK A FLUTE-PLAYER.

Take a common tuning-fork, and on one of its branches fasten with sealing-wax a circular piece of card of the size of a small wafer, or sufficient nearly to cover the aperture of a pipe, as the sliding of the upper end of a flute with the mouth stopped: it may be tuned in unison with the loaded tuning-fork by means of the movable stopper or card, or the fork may be loaded till the unison is perfect. Then set the fork in vibration by a blow on the unloaded branch, and hold the card closely over the mouth of the pipe, as in the engraving, when a note of surprising clearness and strength will be heard. Indeed a flute may be made to "speak" perfectly well, by holding close to the opening a vibrating tuning-fork, while the fingering proper to the note of the fork is at the same time performed.

THEORY OF THE JEW'S HARP.

If you cause the tongue of this little instrument to vibrate, it will produce a very low sound; but if you place it before a cavity (as the mouth) containing a column of air, which vibrates much faster, but in the proportion of any simple multiple, it will then produce other higher sounds, dependent upon the reciprocation of that portion of the air. Now the bulk of air in the mouth can be altered in its form, size, and other circumstances, so as to produce by reciprocation many different sounds; and these are the sounds belonging to the Jew's Harp.

A proof of this fact has been given by Mr. Eulenstein, who fitted into a long metallic tube a piston, which being moved, could be made to lengthen or shorten the efficient column of air within at pleasure. A Jew's Harp was then so fixed that it could be made to vibrate before the mouth of the tube, and it was found that the column of air produced a series of sounds, according as it was lengthened or shortened; a sound being produced whenever the length of the column was such that its vibrations were a multiple of those of the Jew's Harp.

SOLAR AND ARTIFICIAL LIGHT COMPARED.

The most intensely ignited solid (produced by the flame of Lieutenant Drummond's oxy-hydrogen lamp directed against a surface of chalk) appears only as black spots on the disc of the sun, when held between it and the eye; or in other words, Drummond's light is to the light of the sun's disc as 1 to 146. Hence we are doubly struck by the felicity with which Galileo, as early as 1612, by a series of conclusions on the smallness of the distance from the sun at which the disc of Venus was no longer visible to the naked eye, arrived at the result that the blackest nucleus of the sun's spots was more luminous than the brightest portions of the full moon. (See "The Sun's Light compared with Terrestrial Lights," in *Things not generally Known*, pp. 4, 5.)

SOURCE OF LIGHT.

Mr. Robert Hunt, in a lecture delivered by him at the Russell Institution, "On the Physics of a Sunbeam," mentions some experiments by Lord Brougham on the sunbeam, in which, by placing the edge of a sharp knife just within the limit of the light, the ray was inflected from its previous direction, and coloured red; and when another knife was placed on the opposite side, it was deflected, and the colour was blue. These experiments (says Mr. Hunt) seem to confirm Sir Isaac Newton's theory, that light is a fluid emitted from the sun.

THE UNDULATORY SCALE OF LIGHT.

The white light of the sun is well known to be composed of several coloured rays; or rather, according to the theory of undulations, when the rate at which a ray vibrates is altered, a different sensation is produced upon the optic nerve. The analytical examination of this question shows that to produce a red colour the ray of light must give 37,640 undulations in an inch, and 458,000,000,000,000 in a second. Yellow light requires 44,000 undulations in an inch, and 535,000,000,000,000 in a second; whilst the effect of blue results from 51,110 undulations within an inch, and 622,000,000,000,000 of waves in a second of time.—*Hunt's Poetry of Science.*

VISIBILITY OF OBJECTS.

In terrestrial objects, the form, no less than the modes of illumination, determines the magnitude of the smallest angle of vision for the naked eye. Adams very correctly observed that a long and slender staff can be seen at a much greater distance than a square whose sides are equal to the diameter of the staff. A stripe may be distinguished at a greater distance than a spot, even when both are of the same diameter.

The *minimum* optical visual angle at which terrestrial objects can be recognised by the naked eye has been gradually estimated lower and lower, from the time when Robert Hooke fixed it exactly at a full minute, and Tobias Meyer required 34″ to perceive a black speck on white paper, to the period of Leuwenhoeck's experiments with spiders' threads, which are visible to ordinary sight at an angle of 4″·7. In Hueck's most accurate experiments on the problem of the movement of the crystalline lens, white lines on a black ground were seen at an angle of 1″·2; a spider's thread at 0″·6; and a fine glistening wire at scarcely 0″·2.

Humboldt, when at Chillo, near Quito, where the crests of the volcano of Pichincha lay at a horizontal distance of 90,000 feet, was much struck by the circumstance that the Indians standing near distinguished the figure of Bonpland (then on an expedition to the volcano), as a white point moving on the black basaltic sides of the rock, sooner than Humboldt could discover him with a telescope. Bonpland was enveloped in a white cotton poncho: assuming the breadth across the shoulders to vary from three to five feet, according as the mantle clung to the figure or fluttered in the breeze, and judging from the known distance, the angle at which the moving object could be distinctly seen varied from 7″ to 12″. White objects on a black ground are, according to Hueck, distinguished at a greater distance than black objects on a white ground.

Gauss's heliotrope light has been seen with the naked eye reflected from the Brocken on Hobenhagen at a distance of about 227,000 feet, or more than 42 miles; being frequently visible at points in which the apparent breadth of a three-inch mirror was only 0″·43.

THE SMALLEST BRIGHT BODIES.

Ehrenberg has found from experiments on the dust of diamonds, that a diamond superficies of $\frac{1}{100}$th of a line in diameter presents a much more vivid light to the naked eye than one of quicksilver of the same diameter. On pressing small globules of quicksilver on a glass micrometer, he easily obtained smaller globules of the $\frac{1}{100}$th to the $\frac{1}{2000}$th of a line in diameter. In the sunshine he could only discern the reflection of light, and the existence of such globules as were $\frac{1}{300}$th of a line in diameter, with the naked eye. Smaller ones did not affect his eye; but he remarked that the actual bright part of the globule did not amount to more than $\frac{1}{900}$th of a line in diameter. Spider-threads of $\frac{1}{2000}$th in diameter were still discernible from their lustre. Ehrenberg concludes that there are in organic bodies magnitudes capable of direct proof which are in diameter $\frac{1}{100000}$ of a line; and others, that can be indirectly proved, which may be less than a six-millionth part of a Parisian line in diameter.

VELOCITY OF LIGHT.

It is scarcely possible so to strain the imagination as to conceive the Velocity with which Light travels. "What mere assertion will make any man believe," asks Sir John Herschel, "that in one second of time, in one beat of the pendulum of a clock, a ray of light travels over 192,000 miles; and would therefore perform the tour of the world in about the same time that it requires to wink with our eyelids, and in much less time than a swift runner occupies in taking a single stride?" Were a cannon-ball shot directly towards the sun, and were it to maintain its full speed, it would be twenty years in reaching it; and yet light travels through this space in seven or eight minutes.

The result given in the *Annuaire* for 1842 for the velocity of light in a second is 77,000 leagues, which corresponds to 215,834 miles; while that obtained at the Pulkowa Observatory is 189,746 miles. William Richardson gives as the result of the passage of light from the sun to the earth 8′ 19″·28, from which we obtain a velocity of 215,392 miles in a second.—*Memoirs of the Astronomical Society*, vol. iv.

In other words, light travels a distance equal to eight times the circumference of the earth between two beats of a clock. This is a prodigious velocity; but the measure of it is very certain.—*Professor Airy.*

The navigator who has measured the earth's circuit by his hourly progress, or the astronomer who has paced a degree of the meridian, can alone form a clear idea of velocity, when we tell him that light moves through a space equal to the circumference of the earth in *the eighth part of a second*—in the twinkling of an eye.

Could an observer, placed in the centre of the earth, see this moving light, as it describes the earth's circumference, it would appear a luminous ring; that is, the impression of the light at the commencement of its journey would continue on the retina till the light had completed its circuit. Nay, since the impression of light continues longer than the *fourth* part of a second, *two* luminous rings would be seen, provided the light made *two* rounds of the earth, and in paths not coincident.

APPARATUS FOR THE MEASUREMENT OF LIGHT.

Humboldt enumerates the following different methods adopted for the Measurement of Light: a comparison of the shadows of artificial lights, differing in numbers and distance; diaphragms; plane-glasses of different thickness and colour; artificial stars formed by reflection on glass spheres; the juxtaposition of two seven-feet telescopes, separated by a distance which the observer could pass in about a second; reflecting instruments in which two stars can be simultaneously seen and compared, when the telescope has been so adjusted that the star gives two images of like intensity; an apparatus having (in front of the object-glass) a mirror and diaphragms, whose rotation is measured on a ring; telescopes with divided object-glasses, on either half of which the stellar light is received through a prism; astrometers, in which a prism reflects the image of the moon or Jupiter, and concentrates it through a lens at different distances into a star more or less bright.—*Cosmos*, vol. iii.

HOW FIZEAU MEASURED THE VELOCITY OF LIGHT.

This distinguished physicist has submitted the Velocity of Light to terrestrial measurement by means of an ingeniously constructed apparatus, in which artificial light (resembling stellar light), generated from oxygen and hydrogen, is made to pass back, by means of a mirror, over a distance of 28,321 feet to the same point from which it emanated. A disc, having 720 teeth, which made 12·6 rotations in a second, alternately obscured the ray of light and allowed it to be seen between the teeth on the margin. It was supposed, from the marking of a counter, that the artificial light traversed 56,642 feet, or the distance to and from the stations, in $\frac{1}{1800}$th part of a second, whence we obtain a velocity of 191,460 miles in a second.* This result approximates most closely to Delambre's (which was 189,173 miles), as obtained from Jupiter's satellites.

The invention of the rotating mirror is due to Wheatstone, who made an experiment with it to determine the velocity of the propagation of the discharge of a Leyden battery. The most striking application of the idea was made by Fizeau and Foucault, in 1853, in carrying out a proposition made by Arago, soon after the invention of the mirror: we have here determined in a distance of twelve feet no less than the velocity with which light is propagated, which is known to be nearly 200,000 miles a second; the distance mentioned corresponds therefore to the 77-millionth part of a second. The object of these measurements was to compare the velocity of light in air with its velocity in water; which, when the length is greater, is not sufficiently transparent. The most complete optical and mechanical aids are here necessary: the mirror of Foucault made from 600 to 800 revolutions in a second, while that of Fizeau performed 1200 to 1500 in the same time.—*Prof. Helmholtz on the Methods of Measuring very small Portions of Time.*

WHAT IS DONE BY POLARISATION OF LIGHT.

Malus, in 1808, was led by a casual observation of the light of the setting sun, reflected from the windows of the Palais de Luxembourg, at Paris, to investigate more thoroughly the phenomena of double refraction, of ordinary and of chromatic polarisation, of interference and of diffraction of light. Among his results may be reckoned the means of distinguishing between direct and reflected light; the power of penetrating, as it were, into the constitution of the body of the sun and of its luminous envelopes; of measuring the pressure of atmospheric strata, and even the smallest amount of water they contain; of ascertaining the depths of the ocean and its rocks by means of a tourmaline plate; and in accordance with Newton's prediction, of comparing the chemical composition of several substances with their optical effects.

Arago, in a letter to Humboldt, states that by the aid of his polariscope, he discovered, before 1820, that the light of all terrestrial objects in a state of incandescence, whether they be solid or liquid, is natural, so long as it emanates from the object in perpendicular rays. On the other hand, if such light emanate at an acute angle, it presents manifest proofs of polarisation. This led M. Arago to the remarkable conclusion, that light is not generated on the surface of bodies only, but that some portion is actually engendered within the substance itself, even in the case of platinum.

A ray of light which reaches our eyes after traversing many millions of miles, from the remotest regions of heaven, announces, as it were of itself, in the polariscope, whether it is reflected or refracted, whether it emanates from a solid or fluid or gaseous body; it announces even the degree of its intensity. —*Humboldt's Cosmos,* vols. i. and ii.

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* Fizeau gives his result in leagues, reckoning twenty-five to the equatorial degree. He estimates the velocity of light at 70,000 such leagues, or about 210,000 miles in the second.

MINUTENESS OF LIGHT.

There is something wonderful, says Arago, in the experiments which have led natural philosophers legitimately to talk of the different sides of a ray of light; and to show that millions and millions of these rays can simultaneously pass through the eye of a needle without interfering with each other!

THE IMPORTANCE OF LIGHT.

Light affects the respiration of animals just as it affects the respiration of plants. This is novel doctrine, but it is demonstrable. In the day-time we expire more carbonic acid than during the night; a fact known to physiologists, who explain it as the effect of sleep: but the difference is mainly owing to the presence or absence of sunlight; for sleep, as sleep, *increases,* instead of diminishing, the amount of carbonic acid expired, and a man sleeping will expire more carbonic acid than if he lies quietly awake under the same conditions of light and temperature; so that if less is expired during the night than during the day, the reason cannot be sleep, but the absence of light. Now we understand why men are sickly and stunted who live in narrow streets, alleys, and cellars, compared with those who, under similar conditions of poverty and dirt, live in the sunlight.—*Blackwood's Edinburgh Magazine,* 1858.

The influence of light on the colours of organised creation is well shown in the sea. Near the shores we find seaweeds of the most beautiful hues, particularly on the rocks which are left dry by the tides; and the rich tints of the actiniæ which inhabit shallow water must often have been observed. The fishes which swim near the surface are also distinguished by the variety of their colours, whereas those which live at greater depths are gray, brown, or black. It has been found that after a certain depth, where the quantity of light is so reduced that a mere twilight prevails, the inhabitants of the ocean become nearly colourless. —*Hunt's Poetry of Science.*

ACTION OF LIGHT ON MUSCULAR FIBRES.

That light is capable of acting on muscular fibres, independently of the influence of the nerves, was mentioned by several of the old anatomists, but repudiated by later authorities. M. Brown Séquard has, however, proved to the Royal Society that some portions of muscular fibre—the iris of the eye, for example—are affected by light independently of any reflex action of the nerves, thereby confirming former experiences. The effect is produced by the illuminating rays only, the chemical and heat rays remaining neutral. And not least remarkable is the fact, that the iris of an eel showed itself susceptible of the excitement *sixteen days after the eyes were removed from the creature's head.* So far as is yet known, this muscle is the only one on which light thus takes effect.—*Phil. Trans.* 1857.

LIGHT NIGHTS.

It is not possible, as well-attested facts prove, perfectly to explain the operations at work in the much-contested upper boundaries of our atmosphere. The extraordinary lightness of whole nights in the year 1831, during which small print might be read at midnight in the latitudes of Italy and the north of Germany, is a fact directly at variance with all that we know, according to the most recent and acute researches on the crepuscular theory and the height of the atmosphere.—*Biot.*

PHOSPHORESCENCE OF PLANTS.

Mr. Hunt recounts these striking instances. The leaves of the *œnothera macrocarpa* are said to exhibit phosphoric light when the air is highly charged with electricity. The agarics of the olive-grounds of Montpelier too have been observed to be luminous at night; but they are said to exhibit no light, even in darkness, *during the day.* The subterranean passages of the coal-mines near Dresden are illuminated by the phosphorescent light of the *rhizomorpha phosphoreus,* a peculiar fungus. On the leaves of the Pindoba palm grows a species of agaric which is exceedingly luminous at night; and many varieties of the lichens, creeping along the roofs of caverns, lend to them an air of enchantment by the soft and clear light which they diffuse. In a small cave near Penryn, a luminous moss is abundant; it is also found in the mines of Hesse. According to Heinzmann, the *rhizomorpha subterranea* and *aidulæ* are also phosphorescent.—See *Poetry of Science.*

PHOSPHORESCENCE OF THE SEA.

By microscopic examination of the myriads of minute insects which cause this phenomenon, no other fact has been elicited than that they contain a fluid which, when squeezed out, leaves a train of light upon the surface of the water. The creatures appear almost invariably on the eve of some change of weather, which would lead us to suppose that their luminous phenomena must be connected with electrical excitation; and of this Mr. C. Peach of Fowey has furnished the most satisfactory proofs yet obtained.*

LIGHT FROM THE JUICE OF A PLANT.

In Brazil has been observed a plant, conjectured to be an

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* See *Things not generally Known,* p. 88.

Euphorbium, very remarkable for the light which it yields when cut. It contains a milky juice, which exudes as soon as the plant is wounded, and appears luminous for several seconds.

LIGHT FROM FUNGUS.

Phosphorescent funguses have been found in Brazil by Mr. Gardner, growing on the decaying leaves of a dwarf palm. They vary from one to two inches across, and the whole plant gives out at night a bright phosphorescent light, of a pale greenish hue, similar to that emitted by fire-flies and phosphorescent marine animals. The light given out by a few of these fungi in a dark room is sufficient to read by. A very large phosphorescent species is occasionally found in the Swan River colony.

LIGHT FROM BUTTONS.

Upon highly polished gilt buttons no figure whatever can be seen by the most careful examination; yet, when they are made to reflect the light of the sun or of a candle upon a piece of paper held close to them, they give a beautiful geometrical figure, with ten rays issuing from the centre, and terminating in a luminous rim.

COLOURS OF SCRATCHES.

An extremely fine scratch on a well-polished surface may be regarded as having a concave, cylindrical, or at least a curved surface, capable of reflecting light in all directions; this is evident, for it is visible in all directions. Hence a single scratch or furrow in a surface may produce colours by the interference of the rays reflected from its opposite edges. Examine a spider's thread in the sunshine, and it will gleam with vivid colours. These may arise from a similar cause; or from the thread itself, as spun by the animal, consisting of several threads agglutinated together, and thus presenting, not a cylindrical, but a furrowed surface.

MAGIC BUST.

Sir David Brewster has shown how the rigid features of a white bust may be made to move and vary their expression, sometimes smiling and sometimes frowning, by moving rapidly in front of the bust a bright light, so as to make the lights and shadows take every possible direction and various degrees of intensity; and if the bust be placed before a concave mirror, its image may be made to do still more when it is cast upon wreaths of smoke.

COLOURS HIT MOST FREQUENTLY DURING BATTLE.

It would appear from numerous observations that soldiers are hit during battle according to the colour of their dress in the following order: red is the most fatal colour; the least fatal, Austrian gray. The proportions are, red, 12; rifle-green, 7; brown, 6; Austrian bluish-gray, 5.—*Jameson's Journal*, 1853.

TRANSMUTATION OF TOPAZ.

Yellow topazes may be converted into pink by heat; but it is a mistake to suppose that in the process the yellow colour is changed into pink: the fact is, that one of the pencils being yellow and the other pink, the yellow is discharged by heat, thus leaving the pink unimpaired.

COLOURS AND TINTS.

M. Chevreul, the *Directeur des Gobelins*, has presented to the French Academy a plan for a universal chromatic scale, and a methodical classification of all imaginable colours. Mayer, a professor at Göttingen, calculated that the different combinations of primitive colours produced 819 different tints; but M. Chevreul established not less than 14,424, all very distinct and easily recognised,—all of course proceeding from the three primitive simple colours of the solar spectrum, red, yellow, and blue. For example, he states that in the violet there are twenty-eight colours, and in the dahlia forty-two.

OBJECTS REALLY OF NO COLOUR.

A body appears to be of the colour which it reflects; as we see it only by reflected rays, it can but appear of the colour of those rays. Thus grass is green because it absorbs all except the green rays. Flowers, in the same manner, reflect the various colours of which they appear to us: the rose, the red rays; the violet, the blue; the daffodil, the yellow, &c. But these are not the permanent colours of the grass and flowers; for wherever you see these colours, the objects must be illuminated; and light, from whatever source it proceeds, is of the same nature, composed of the various coloured rays which paint the grass, the flowers, and every coloured object in nature. Objects in the dark have no colour, or are black, which is the same thing. You can never see objects without light. Light is composed of colours, therefore there can be no light without colours; and though every object is black or without colour in the dark, it becomes coloured as soon as it becomes visible.

THE DIORAMA—WHY SO PERFECT AN ILLUSION.

Because when an object is viewed at so great a distance that the optic axes of both eyes are sensibly parallel when directed towards it, the perspective projections of it, seen by each eye separately, are similar; and the appearance to the two eyes is precisely the same as when the object is seen by one eye only. There is, in such case, no difference between the visual appearance of an object in relief and its perspective projection on a plane surface; hence pictorial representations of distant objects, when those circumstances which would prevent or disturb the illusion are carefully excluded, may be rendered such perfect resemblances of the objects they are intended to represent as to be mistaken for them. The Diorama is an instance of this.—*Professor Wheatstone; Philosophical Transactions*, 1838.

CURIOUS OPTICAL EFFECTS AT THE CAPE.

Sir John Herschel, in his observatory at Feldhausen, at the base of the Table Mountain, witnessed several curious optical effects, arising from peculiar conditions of the atmosphere incident to the climate of the Cape. In the hot season "the nights are for the most part superb;" but occasionally, during the excessive heat and dryness of the sandy plains, "the optical tranquillity of the air" is greatly disturbed. In some cases, the images of the stars are violently dilated into nebular balls or puffs of 15′ in diameter; on other occasions they form "soft, round, quiet pellets of 3′ or 4′ diameter," resembling planetary nebulæ. In the cooler months the tranquillity of the image and the sharpness of vision are such, that hardly any limit is set to magnifying power but that which arises from the aberration of the specula. On occasions like these, optical phenomena of extraordinary splendour are produced by viewing a bright star through a diaphragm of cardboard or zinc pierced in regular patterns of circular holes by machinery: these phenomena surprise and delight every person that sees them. When close double stars are viewed with the telescope, with a diaphragm in the form of an equilateral triangle, the discs of the two stars, which are exact circles, have a clearness and perfection almost incredible.

THE TELESCOPE AND THE MICROSCOPE.

So singular is the position of the Telescope and the Microscope among the great inventions of the age, that no other process but that which they embody could make the slightest approximation to the secrets which they disclose. The steam-engine might have been imperfectly replaced by an air or an ether-engine; and a highly elastic fluid might have been, and may yet be, found, which shall impel the "rapid car," or drag the merchant-ship over the globe. The electric telegraph, now so perfect and unerring, might have spoken to us in the rude "language of chimes;" or sound, in place of electricity, might have passed along the metallic path, and appealed to the ear in place of the eye. For the printing-press and the typographic art might have been found a substitute, however poor, in the lithographic process; and knowledge might have been widely diffused by the photographic printing powers of the sun, or even artificial light. But without the telescope and the microscope, the human eye would have struggled in vain to study the worlds beyond our own, and the elaborate structures of the organic and inorganic creation could never have been revealed.—*North-British Review*, No. 50.

INVENTION OF THE MICROSCOPE.

The earliest magnifying lens of which we have any knowledge was one rudely made of rock-crystal, which Mr. Layard found, among a number of glass bowls, in the north-west palace of Nimroud; but no similar lens has been found or described to induce us to believe that the microscope, either single or compound, was invented and used as an instrument previous to the commencement of the seventeenth century. In the beginning of the first century, however, Seneca alludes to the magnifying power of a glass globe filled with water; but as he only states that it made small and indistinct letters appear larger and more distinct, we cannot consider such a casual remark as the invention of the single microscope, though it might have led the observer to try the effect of smaller globes, and thus obtain magnifying powers sufficient to discover phenomena otherwise invisible.

Lenses of glass were undoubtedly in existence at the time of Pliny; but at that period, and for many centuries afterwards, they appear to have been used only as burning or as reading glasses; and no attempt seems to have been made to form them of so small a size as to entitle them to be regarded even as the precursors of the single microscope.—*North-British Review*, No. 50.

The *rock-crystal lens* found at Nineveh was examined by Sir David Brewster. It was not entirely circular in its aperture. Its general form was that of a plano-convex lens, the plane side having been formed of one of the original faces of the six-sided crystal quartz, as Sir David ascertained by its action on polarised light: this was badly polished and scratched. The convex face of the lens had not been ground in a dish-shaped tool, in the manner in which lenses are now formed, but was shaped on a lapidary's wheel, or in some such manner. Hence it was unequally thick; but its extreme thickness was $\frac{2}{10}$ths of an inch, its focal length being 4½ inches. It had twelve remains of cavities, which had originally contained liquids or condensed gases. Sir David has assigned reasons why this could not be looked upon as an ornament, but a true optical lens. In the same ruins were found some decomposed glass.

HOW TO MAKE THE FISH-EYE MICROSCOPE.

Very good microscopes may be made with the crystalline lenses of fish, birds, and quadrupeds. As the lens of fishes is spherical or spheroidal, it is absolutely necessary, previous to its use, to determine its optical axis and the axis of vision of the eye from which it is taken, and place the lens in such a manner that its axis is a continuation of the axis of our own eye. In no other direction but this is the albumen of which the lens consists symmetrically disposed in laminæ of equal density round a given line, which is the axis of the lens; and in no other direction does the gradation of density, by which the spherical aberration is corrected, preserve a proper relation to the axis of vision.

When the lens of any small fish, such as a minnow, a par, or trout, has been taken out, along with the adhering vitreous humour, from the eye-ball by cutting the sclerotic coat with a pair of scissors, it should be placed upon a piece of fine silver-paper previously freed from its minute adhering fibres. The absorbent nature of the paper will assist in removing all the vitreous humour from the lens; and when this is carefully done, by rolling it about with another piece of silver-paper, there will still remain, round or near the equator of the lens, a black ridge, consisting of the processes by which it was suspended in the eye-ball. The black circle points out to us the true axis of the lens, which is perpendicular to a plane passing through it. When the small crystalline has been freed from all the adhering vitreous humour, the capsule which contains it will have a surface as fine as a pellicle of fluid. It is then to be dropped from the paper into a cavity formed by a brass rim, and its position changed till the black circle is parallel to the circular rim, in which case only the axis of the lens will be a continuation of the axis of the observer's eye.—*Edin. Jour. Science,* vol. ii.

LEUWENHOECK'S MICROSCOPES.

Leuwenhoeck, the father of microscopical discovery, communicated to the Royal Society, in 1673, a description of the structure of a bee and a louse, seen by aid of his improved microscopes; and from this period until his decease in 1723, he regularly transmitted to the society his microscopical observations and discoveries, so that 375 of his papers and letters are preserved in the society's archives, extending over fifty years. He further bequeathed to the Royal Society a cabinet of twenty-six microscopes, which he had ground himself and set in silver, mostly extracted by him from minerals; these microscopes were exhibited to Peter the Great when he was at Delft in 1698. In acknowledging the bequest, the council of the Royal Society, in 1724, presented Leuwenhoeck's daughter with a handsome silver bowl, bearing the arms of the society.—*Weld's History of the Royal Society,* vol. i.

DIAMOND LENSES FOR MICROSCOPES.

In recommending the employment of Diamond and other gems in the construction of Microscopes, Sir David Brewster has been met with the objection that they are too expensive for such a purpose; and, says Sir David, "they certainly are for instruments intended merely to instruct and amuse. But if we desire to make great discoveries, to unfold secrets yet hid in the cells of plants and animals, we must not grudge even a diamond to reveal them. If Mr. Cooper and Sir James South have given a couple of thousand pounds a piece for a refracting telescope, in order to study what have been miscalled 'dots' and 'lumps' of light on the sky; and if Lord Rosse has expended far greater sums on a reflecting telescope for analysing what has been called 'sparks of mud and vapour' encumbering the azure purity of the heavens,—why should not other philosophers open their purse, if they have one, and other noblemen sacrifice some of their household jewels, to resolve the microscopic structures of our own real world, and disclose secrets which the Almighty must have intended that we should know?" —*Proceedings of the British Association*, 1857.

THE EYE AND THE BRAIN SEEN THROUGH A MICROSCOPE.

By a microscopic examination of the retina and optic nerve and the brain, M. Bauer found them to consist of globules of $\frac{1}{2800}$th to $\frac{1}{4000}$th of an inch diameter, united by a transparent viscid and coagulable gelatinous fluid.

MICROSCOPICAL EXAMINATION OF THE HAIR.

If a hair be drawn between the finger and thumb, from the end to the root, it will be distinctly felt to give a greater resistance and a different sensation to that which is experienced when drawn the opposite way: in consequence, if the hair be rubbed between the fingers, it will only move one way (travelling in the direction of a line drawn from its termination to its origin from the head or body), so that each extremity may thus be easily distinguished, even in the dark, by the touch alone.

The mystery is resolved by the achromatic microscope. A hair viewed on a dark ground as an *opaque* object with a high power, not less than that of a lens of one-thirtieth of an inch focus, and dully illuminated by a *cup*, the hair is seen to be indented with teeth somewhat resembling those of a coarse round rasp, but extremely irregular and rugged: as these incline all in one direction, like those of a common file, viz. from the origin of the hair towards its extremity, it sufficiently explains the above singular property.

This is a singular proof of the acuteness of the sense of feeling, for the said teeth may be felt much more easily than they can be seen. We may thus understand why a razor will cut a hair in two much more easily when drawn against its teeth than in the opposite direction.—*Dr. Goring.*

THE MICROSCOPE AND THE SEA.

What myriads has the microscope revealed to us of the rich luxuriance of animal life in the ocean, and conveyed to our astonished senses a consciousness of the universality of life! In the oceanic depths every stratum of water is animated, and swarms with countless hosts of small luminiferous animalcules, mammaria, crustacea, peridinea, and circling nereides, which, when attracted to the surface by peculiar meteorological conditions, convert every wave into a foaming band of flashing light.

USE OF THE MICROSCOPE TO MINERALOGISTS.

M. Dufour has shown that an imponderable quantity of a substance can be crystallised; and that the crystals so obtained are quite characteristic of the substances, as of sugar, chloride of sodium, arsenic, and mercury. This process may be extremely valuable to the mineralogist and toxicologist when the substance for examination is too small to be submitted to tests. By aid of the microscope, also, shells are measured to the thousandth part of an inch.

FINE DOWN OF QUARTZ.

Sir David Brewster having broken in two a crystal of quartz of a smoky colour, found both surfaces of the fracture absolutely black; and the blackness appeared at first sight to be owing to a thin film of opaque matter which had insinuated itself into the crevice. This opinion, however, was untenable, as every part of the surface was black, and the two halves of the crystals could not have stuck together had the crevice extended across the whole section. Upon further examination Sir David found that the surface was perfectly transparent by transmitted light, and that the blackness of the surfaces arose from their being entirely composed of *a fine down of quartz,* or of short and slender filaments, whose diameter was so exceedingly small that they were incapable of reflecting a single ray of the strongest light; and they could not exceed the *one-third of the millionth part of an inch.* This curious specimen is in the cabinet of her grace the Duchess of Gordon.

MICROSCOPIC WRITING.

Professor Kelland has shown, in Paris, on a spot no larger than the head of a small pin, by means of powerful microscopes, several specimens of distinct and beautiful writing, one of them containing the whole of the Lord's Prayer written within this minute compass. In reference to this, two remarkable facts in Layard's latest work on Nineveh show that the national records of Assyria were written on square bricks, in characters so small as scarcely to be legible without a microscope; in fact, a microscope, as we have just shown, was found in the ruins of Nimroud.

HOW TO MAKE A MAGIC MIRROR.

Draw a figure with weak gum-water upon the surface of a convex mirror. The thin film of gum thus deposited on the outline or details of the figure will not be visible in dispersed daylight; but when made to reflect the rays of the sun, or those of a divergent pencil, will be beautifully displayed by the lines and tints occasioned by the diffraction of light, or the interference of the rays passing through the film with those which pass by it.

SIR DAVID BREWSTER'S KALEIDOSCOPE.

The idea of this instrument, constructed for the purpose of creating and exhibiting a variety of beautiful and perfectly symmetrical forms, first occurred to Sir David Brewster in 1814, when he was engaged in experiments on the polarisation of light by successive reflections between plates of glass. The reflectors were in some instances inclined to each other; and he had occasion to remark the circular arrangement of the images of a candle round a centre, or the multiplication of the sectors formed by the extremities of the glass plates. In repeating at a subsequent period the experiments of M. Biot on the action of fluids upon light, Sir David Brewster placed the fluids in a trough, formed by two plates of glass cemented together at an angle; and the eye being necessarily placed at one end, some of the cement, which had been pressed through between the plates, appeared to be arranged into a regular figure. The remarkable symmetry which it presented led to Dr. Brewster's investigation of the cause of this phenomenon; and in so doing he discovered the leading principles of the Kaleidoscope.

By the advice of his friends, Dr. Brewster took out a patent for his invention; in the specification of which he describes the kaleidoscope in two different forms. The instrument, however, having been shown to several opticians in London, became known before he could avail himself of his patent; and being simple in principle, it was at once largely manufactured. It is calculated that not less than 200,000 kaleidoscopes were sold in three months in London and Paris; though out of this number, Dr. Brewster says, not perhaps 1000 were constructed upon scientific principles, or were capable of giving any thing like a correct idea of the power of his kaleidoscope.

THE KALEIDOSCOPE THOUGHT TO BE ANTICIPATED.

In the seventh edition of a work on gardening and planting, published in 1739, by Richard Bradley, F.R.S., late Professor of Botany in the University of Cambridge, we find the following details of an invention, "by which the best designers and draughtsmen may improve and help their fancies. They must choose two pieces of looking-glass of equal bigness, of the figure of a long square. These must be covered on the back with paper or silk, to prevent rubbing off the silver. This covering must be so put on that nothing of it appears about the edges of the bright side. The glasses being thus prepared, must be laid face to face, and hinged together so that they may be made to open and shut at pleasure like the leaves of a book." After showing how various figures are to be looked at in these glasses under the same opening, and how the same figure may be varied under the different openings, the ingenious artist thus concludes: "If it should happen that the reader has any number of plans for parterres or wildernesses by him, he may by this method alter them at his pleasure, and produce such innumerable varieties as it is not possible the most able designer could ever have contrived."

MAGIC OF PHOTOGRAPHY.

Professor Moser of Königsberg has discovered that all bodies, even in the dark, throw out invisible rays; and that these bodies, when placed at a small distance from polished surfaces of all kinds, depict themselves upon such surfaces in forms which remain invisible till they are developed by the human breath or by the vapours of mercury or iodine. Even if the sun's image is made to pass over a plate of glass, the light tread of its rays will leave behind it an invisible track, which the human breath will instantly reveal.

Among the early attempts to take pictures by the rays of the sun was a very interesting and successful experiment made by Dr. Thomas Young. In 1802, when Mr. Wedgewood was "making profiles by the agency of light," and Sir Humphry Davy was "copying on prepared paper the images of small objects produced by means of the solar microscope," Dr. Young was taking photographs upon paper dipped in a solution of nitrate of silver, of the coloured rings observed by Newton; and his experiments clearly proved that the agent was not the luminous rays in the sun's light, but the invisible or chemical rays beyond the violet. This experiment is described in the Bakerian Lecture, 1803.

Niepce (says Mr. Hunt) pursued a physical investigation of the curious change, and found that all bodies were influenced by this principle radiated from the sun. Daguerre* produced effects from the solar pencil which no artist could approach; and Talbot and others extended the application. Herschel took up the inquiry; and he, with his usual power of inductive search and of philosophical deduction, presented the world with a class of discoveries which showed how vast a field of investigation was opening for the younger races of mankind.

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* Some time before the first announcement of the discovery of sun-painting, the following extract from Sir John Herschel's *Treatise on Light*, in the *Encyclopædia Metropolitana*, appeared in a popular work entitled *Parlour Magic:* "Strain a piece of paper or linen upon a wooden frame, and sponge it over with a solution of nitrate of silver in water; place it behind a painting upon glass, or a stained window-pane, and the light, traversing the painting or figures, will produce a copy of it upon the prepared paper or linen; those parts in which the rays were least intercepted being the shadows of the picture."

The first attempts in photography, which were made at the instigation of M. Arago, by order of the French Government, to copy the Egyptian tombs and temples and the remains of the Aztecs in Central America, were failures. Although the photographers employed succeeded to admiration, in Paris, in producing pictures in a few minutes, they found often that an exposure of an hour was insufficient under the bright and glowing illumination of a southern sky.

THE BEST SKY FOR PHOTOGRAPHY.

Contrary to all preconceived ideas, experience proves that the brighter the sky that shines above the camera the more tardy the action within it. Italy and Malta do their work slower than Paris. Under the brilliant light of a Mexican sun, half an hour is required to produce effects which in England would occupy but a minute. In the burning atmosphere of India, though photographical the year round, the process is comparatively slow and difficult to manage; while in the clear, beautiful, and moreover cool, light of the higher Alps of Europe, it has been proved that the production of a picture requires many more minutes, even with the most sensitive preparations, than in the murky atmosphere of London. Upon the whole, the temperate skies of this country may be pronounced favourable to photographic action; a fact for which the prevailing characteristic of our climate may partially account, humidity being an indispensable condition for the working state both of paper and chemicals.—*Quarterly Review*, No. 202.

PHOTOGRAPHIC EFFECTS OF LIGHTNING.

The following authenticated instances of this singular phenomenon have been communicated to the Royal Society by Andrés Poey, Director of the Observatory at Havana:

Benjamin Franklin, in 1786, stated that about twenty years previous, a man who was standing opposite a tree that had just been struck by "a thunderbolt" had on his breast an exact representation of that tree.

In the New-York *Journal of Commerce*, August 26th, 1853, it is related that "a little girl was standing at a window, before which was a young maple-tree; after a brilliant flash of lightning. a complete image of the tree was found imprinted on her body."

M. Raspail relates that, in 1855, a boy having climbed a tree for the purpose of robbing a bird's nest, tho tree was struck, and the boy thrown upon the ground; on his breast the image of the treo, with the bird and nest on one of its branches, appeared very plainly.

M. Olioli, a learned Italian, brought before the Scientific Congress at Naples the following four instances: 1. In September 1825, the foremast of a brigantine in the Bay of St. Arniro was struck by lightning, when a sailor sitting under the mast was struck dead, and on his back was found an impression of a horse-shoe, similar even in size to that fixed on the mast-head. 2. A sailor, standing in a similar position, was struck by lightning, and had on his left breast the impression of the number 4.4, with a dot between the two figures, just as they appeared at the extremity of one of the masts. 3. On the 9th October 1836, a young man was found struck by lightning; he had on a girdle, with some gold coins in it, which were imprinted on his skin in the order they were placed in the girdle,—a series of circles, with one point of contact, being plainly visible. 4. In 1847, Mme. Morosa, an Italian lady of Lugano, was sitting near a window during a thunderstorm, and perceived the commotion, but felt no injury; but a flower which happened to be in the path of the electric current was perfectly reproduced on one of her legs, and there remained permanently.

M. Poey himself witnessed the following instance in Cuba. On July 24th, 1852, a poplar-tree in a coffee-plantation was struck by lightning, and on one of the large dry leaves was found an exact representation of some pine-trees that lay 367 yards distant.

M. Poey considers these lightning impressions to have been produced in the same manner as the electric images obtained by Moser, Riess, Karster, Grove, Fox Talbot, and others, either by statical or dynamical electricity of different intensities. The fact that impressions are made through the garments is easily accounted for by their rough texture not preventing the lightning passing through them with the impression. To corroborate this view, M. Poey mentions an instance of lightning passing down a chimney into a trunk, in which was found an inch depth of soot, which must have passed through the wood itself.

PHOTOGRAPHIC SURVEYING.

During the summer of 1854, in the Baltic, the British steamers employed in examining the enemy's coasts and fortifications took photographic views for reference and minute examination. With the steamer moving at the rate of fifteen knots an hour, the most perfect definitions of coasts and batteries were obtained. Outlines of the coasts, correct in height and distance, have been faithfully transcribed; and all details of the fortresses passed under this photographic review are accurately recorded.

It is curious to reflect that the aids to photographic development all date within the last half-century, and are but little older than photography itself. It was not until 1811 that the chemical substance called iodine, on which the foundations of all popular photography rest, was discovered at all; bromine, the only other substance equally sensitive, not till 1826. The invention of the electro process was about simultaneous with that of photography itself. Gutta-percha only just preceded the substance of which collodion is made; the ether and chloroform, which are used in some methods, that of collodion. We say nothing of the optical improvements previously contrived or adapted for the purpose of the photograph: the achromatic lenses, which correct the discrepancy between the visual and chemical foci; the double lenses, which increase the force of the action; the binocular lenses, which do the work of the stereoscope; nor of the innumerable other mechanical aids which have sprung up for its use.

THE STEREOSCOPE AND THE PHOTOGRAPH.

When once the availability of one great primitive agent is worked out, it is easy to foresee how extensively it will assist in unravelling other secrets in natural science. The simple principle of the Stereoscope, for instance, might have been discovered a century ago, for the reasoning which led to it was independent of all the properties of light; but it could never have been illustrated, far less multiplied as it now is, without Photography. A few diagrams, of sufficient identity and difference to prove the truth of the principle, might have been constructed by hand, for the gratification of a few sages; but no artist, it is to be hoped, could have been found possessing the requisite ability and stupidity to execute the two portraits, or two groups, or two interiors, or two landscapes, identical in every minutia of the most elaborate detail, and yet differing in point of view by the inch between the two human eyes, by which the principle is brought to the level of any capacity. Here, therefore, the accuracy and insensibility of a machine could alone avail; and if in the order of things the cheap popular toy which the stereoscope now represents was necessary for the use of man, the photograph was first necessary for the service of the stereoscope.—*Quarterly Review*, No. 202.

THE STEREOSCOPE SIMPLIFIED.

When we look at any round object, first with one eye, and then with the other, we discover that with the right eye we see most of the right-hand side of the object, and with the left eye most of the left-hand side. These two images are combined, and we see an object which we know to be round.

This is illustrated by the *Stereoscope*, which consists of two mirrors placed each at an angle of 45 deg., or of two semi-lenses turned with their curved sides towards each other. To view its phenomena two pictures are obtained by the camera on photographic paper of any object in two positions, corresponding with the conditions of viewing it with the two eyes. By the mirrors on the lenses these dissimilar pictures are combined within the eye, and the vision of an actually solid object is produced from the pictures represented on a plane surface. Hence the name of the instrument, which signifies *Solid I see.* —*Hunt's Poetry of Science.*

PHOTO-GALVANIC ENGRAVING.

That which was the chief aid of Niepce in the humblest dawn of the art, viz. to transform the photographic plate into a surface capable of being printed, is in the above process done by the coöperation of Electricity with Photography. This invention of M. Pretsch, of Vienna, differs from all other attempts for the same purpose in not operating upon the photographic tablet itself, and by discarding the usual means of varnishes and bitings-in. The process is simply this: A glass tablet is coated with gelatine diluted till it forms a jelly, and containing bi-chromate of potash, nitrate of silver, and iodide of potassium. Upon this, when dry, is placed face downwards a paper positive, through which the light, being allowed to fall, leaves upon the gelatine a representation of the print. It is then soaked in water; and while the parts acted upon by the light are comparatively unaffected by the fluid, the remainder of the jelly swells, and rising above the general surface, gives a picture in relief, resembling an ordinary engraving upon wood. Of this intaglio a cast is now taken in gutta-percha, to which the electro process in copper being applied, a plate or matrix is produced, bearing on it an exact repetition of the original positive picture. All that now remains to be done is to repeat the electro process; and the result is a copper-plate in the necessary relievo, of which it has been said nature furnished the materials and science the artist, the inferior workman being only needed to roll it through the press.—*Quarterly Review*, No. 202.

SCIENCE OF THE SOAP-BUBBLE.

Few of the minor ingenuities of mankind have amused so many individuals as the blowing of bubbles with soap-lather from the bowl of a tobacco-pipe; yet how few who in childhood's careless hours have thus amused themselves, have in after-life become acquainted with the beautiful phenomena of light which the soap-bubble will enable us to illustrate!

Usually the bubble is formed within the bowl of a tobacco-pipe, and so inflated by blowing through the stem. It is also produced by introducing a capillary tube under the surface of soapy water, and so raising a bubble, which may be inflated to any convenient size. It is then guarded with a glass cover, to prevent its bursting by currents of air, evaporation, and other causes.

When the bubble is first blown, its form is elliptical, into which it is drawn by its gravity being resisted; but the instant it is detached from the pipe, and allowed to float in air, it becomes a perfect sphere, since the air within presses equally in all directions. There is also a strong cohesive attraction in the particles of soap and water, after having been forcibly distended; and as a sphere or globe possesses less surface than any other figure of equal capacity, it is of all forms the best adapted to the closest approximation of the particles of soap and water, which is another reason why the bubble is globular. The film of which the bubble consists is inconceivably thin (not exceeding the two-millionth part of an inch); and by the evaporation from its surface, the contraction and expansion of the air within, and the tendency of the soap-lather to gravitate towards the lower part of the bubble, and consequently to render the upper part still thinner, it follows that the bubble lasts but a few seconds. If, however, it were blown in a glass vessel, and the latter immediately closed, it might remain for some time; Dr. Paris thus preserved a bubble for a considerable period.

Dr. Hooke, by means of the coloured rings upon the soap-bubble, studied the curious subject of the colours of thin plates, and its application to explain the colours of natural bodies. Various phenomena were also discovered by Newton, who thus did not disdain to make a soap-bubble the object of his study. The colours which are reflected from the upper surface of the bubble are caused by the decomposition of the light which falls upon it; and the range of the phenomena is alike extensive and beautiful.*

Newton (says Sir D. Brewster), having covered the soap-bubble with a glass shade, saw its colours emerge in regular order, like so many concentric rings encompassing the top of it. As the bubble grew thinner by the continual subsidence of the water, the rings dilated slowly, and overspread the whole of it, descending to the bottom, where they vanished successively. When the colours had all emerged from the top, there arose in the centre of the rings a small round black spot, dilating it to more than half an inch in breadth till the bubble burst. Upon examining the rings between the object-glasses, Newton found that when they were only *eight* or *nine* in number, more than *forty* could be seen by viewing them through a prism; and even when the plate of air seemed all over uniformly white, multitudes of rings were disclosed by the prism. By means of these observations Newton was enabled to form his *Scale of Colours*, of great value in all optical researches.

Dr. Reade has thus produced a permanent soap-bubble:

> Put into a six-ounce phial two ounces of distilled water, and set the phial in a vessel of water boiling on the fire. The water in the phial will soon boil, and steam will issue from its mouth, expelling the whole of the atmospheric air from within. Then throw in a piece of soap about the size of a small pea, cork the phial, and at the same in-

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* In his book on Colours, Mr. Boyle informs us that divers, if not all, essential oils, as also spirits of wine, when shaken, "have a good store of bubbles, which appear adorned with various and lively colours." He mentions also that bubbles of soap and turpentine exhibit the same colours, which "vary according to the incidence of the sight and the position of the eye;" and he had seen a glass-blower blow bubbles of glass which burst, and displayed "the varying colours of the rainbow, which were exceedingly vivid."

stant remove it and the vessel from the fire. Then press the cork further into the neck of the phial, and cover it thickly with sealing-wax; and when the contents are cold, a perfect vacuum will be formed within the bottle,—much better, indeed, than can be produced by the best-constructed air-pump.

To form a bubble, hold the bottle horizontally in both hands, and give it a sudden upward motion, which will throw the liquid into a wave, whose crest touching the upper interior surface of the phial, the tenacity of the liquid will cause a film to be retained all round the phial. Next place the phial on its bottom; when the film will form a section of the cylinder, being nearly but never quite horizontal. The film will be now colourless, since it reflects all the light which falls upon it. By remaining at rest for a minute or two, minute currents of lather will descend by their gravitating force down the inclined plane formed by the film, the upper part of which thus becomes drained to the necessary thinness; and this is the part to be observed.

Several concentric segments of coloured rings are produced; the colours, beginning from the top, being as follows:

1st order: Black, white, yellow, orange, red.
2d order: Purple, blue, white, yellow, red.
3d order: Purple, blue, green, yellowish-green, white, red.
4th order: Purple, blue, green, white, red.
5th order: Greenish-blue, very pale red.
6th order: Greenish-blue, pink.
7th order: Greenish-blue, pink.

As the segments advance they get broader, while the film becomes thinner and thinner. The several orders disappear upwards as the film becomes too thin to reflect their colours, until the first order alone remains, occupying the whole surface of the film. Of this order the red disappears first, then the orange, and lastly the yellow. The film is now divided by a line into two nearly equal portions, one black and the other white. This remains for some time; at length the film becomes too thin to hold together, and then vanishes. The colours are not faint and imperfect, but well defined, glowing with gorgeous hues, or melting into tints so exquisite as to have no rival through the whole circle of the arts. We quote these details from Mr. Tomlinson's excellent *Student's Manual of Natural Philosophy*.

We find the following anecdote related of Newton at the above period. When Sir Isaac changed his residence, and went to live in St. Martin's Street, Leicester Square, his next-door neighbour was a widow lady, who was much puzzled by the little she observed of the habits of the philosopher. A Fellow of the Royal Society called upon her one day, when, among her domestic news, she mentioned that some one had come to reside in the adjoining house who, she felt certain, was a poor crazy gentleman, "because," she continued, "he diverts himself in the oddest way imaginable. Every morning, when the sun shines so brightly that we are obliged to draw the window-blinds, he takes his seat on a little stool before a tub of soapsuds, and occupies himself for hours blowing soap-bubbles through a common clay-pipe, which bubbles he intently watches floating about till they burst. He is doubtless," she added, "now at his favourite amusement, for it is a fine day; do come and look at him." The gentleman smiled, and they went upstairs; when, after looking through the staircase-window into the adjoining court-yard, he turned and said: "My dear madam, the person whom you suppose to be a poor lunatic is no other than the great Sir Isaac Newton studying the refraction of light upon thin plates; a phenomenon which is beautifully exhibited on the surface of a common soap-bubble."

LIGHT FROM QUARTZ.

Among natural phenomena (says Sir David Brewster) illustrative of the colours of thin plates, we find none more remarkable than one exhibited by the fracture of a large crystal of quartz of a smoky colour, and about two and a quarter inches in diameter. The surface of fracture, in place of being a face or cleavage, or irregularly conchoidal, as we have sometimes seen it, was filamentous, like a surface of velvet, and consisted of short fibres, so small as to be incapable of reflecting light. Their size could not have been greater than the third of the millionth part of an inch, or one-fourth of the thinnest part of the soap-bubble when it exhibits the black spot where it bursts.

CAN THE CAT SEE IN THE DARK?

No, in all probability, says the reader; but the opposite popular belief is supported by eminent naturalists.

Buffon says: "The eyes of the cat shine in the dark somewhat like diamonds, which throw out during the night the light with which they were in a manner impregnated during the day."

Valmont de Bamare says: "The pupil of the cat is during the night still deeply imbued with the light of the day;" and again, "the eyes of the cat are during the night so imbued with light that they then appear very shining and luminous."

Spallanzani says: "The eyes of cats, polecats, and several other animals, shine in the dark like two small tapers;" and he adds that this light is phosphoric.

Treviranus says: "The eyes of the cat *shine where no rays of light penetrate;* and the light must in many, if not in all, cases proceed from the eye itself."

Now, that the eyes of the cat do shine in the dark is to a certain extent true: but we have to inquire whether by *dark* is meant the entire absence of light; and it will be found that the solution of this question will dispose of several assertions and theories which have for centuries perplexed the subject.

Dr. Karl Ludwig Esser has published in Karsten's Archives the results of an experimental inquiry on the luminous appearance of the eyes of the cat and other animals, carefully distinguishing such as evolve light from those which only reflect it. Having brought a cat into a half-darkened room, he observed from a certain direction that the cat's eyes, when *opposite the* *window*, sparkled brilliantly; but in other positions the light suddenly vanished. On causing the cat to be held so as to exhibit the light, and then gradually darkening the room, the light disappeared by the time the room was made quite dark.

In another experiment, a cat was placed opposite the window in a darkened room. A few rays were permitted to enter, and by adjusting the light, one or both of the cat's eyes were made to shine. In proportion as the pupil was dilated, the eyes were brilliant. By suddenly admitting a strong glare of light into the room, the pupil contracted; and then suddenly darkening the room, the eye exhibited a small round luminous point, which enlarged as the pupil dilated.

The eyes of the cat sparkle most when the animal is in a lurking position, or in a state of irritation. Indeed, the eyes of all animals, as well as of man, appear brighter when in rage than in a quiescent state, which Collins has commemorated in his Ode on the Passions:

> "Next Anger rushed, his eyes on fire."

This brilliancy is said to arise from an increased secretion of the lachrymal fluid on the surface of the eye, by which the reflection of the light is increased. Dr. Esser, in places absolutely dark, never discovered the slightest trace of light in the eye of the cat; and he has no doubt that in all cases where cats' eyes have been seen to shine in dark places, such as a cellar, light penetrated through some window or aperture, and fell upon the eyes of the animal as it turned towards the opening, while the observer was favourably situated to obtain a view of the reflection.

To prove more clearly that this light does not depend upon the will of the animal, nor upon its angry passions, experiments were made upon the head of a dead cat. The sun's rays were admitted through a small aperture; and falling immediately upon the eyes, caused them to glow with a beautiful green light more vivid even than in the case of a living animal, on account of the increased dilatation of the pupil. It was also remarked that black and fox-coloured cats gave a brighter light than gray and white cats.

To ascertain the cause of this luminous appearance Dr. Esser dissected the eyes of cats, and exposed them to a small regulated amount of light after having removed different portions. The light was not diminished by the removal of the cornea, but only changed in colour. The light still continued after the iris was displaced; but on taking away the crystalline lens it greatly diminished both in intensity and colour. Dr. Esser then conjectured that the tapetum in the hinder part of the eye must form a spot which caused the reflection of the incident rays of light, and thus produce the shining; and this appeared more probable as the light of the eye now seemed to emanate from a single spot. Having taken away the vitreous humour, Dr. Esser observed that the entire want of the pigment in the hinder part of the choroid coat, where the optic nerve enters, formed a greenish, silver-coloured, changeable oblong spot, which was not symmetrical, but surrounded the optic nerve so that the greater part was above and only the smaller part below it; wherefore the greater part lay beyond the axis of vision. It is this spot, therefore, that produces the reflection of the incident rays of light, and beyond all doubt, according to its tint, contributes to the different colouring of the light.

It may be as well to explain that the interior of the eye is coated with a black pigment, which has the same effect as the black colour given to the inner surface of optical instruments : it absorbs any rays of light that may be reflected within the eye, and prevents them from being thrown again upon the retina so as to interfere with the distinctness of the images formed upon it. The retina is very transparent; and if the surface behind it, instead of being of a dark colour, were capable of reflecting light, the luminous rays which had already acted on the retina would be reflected back again through it, and not only dazzle from excess of light, but also confuse and render indistinct the images formed on the retina. Now in the case of the cat this black pigment, or a portion of it, is wanting; and those parts of the eye from which it is absent, having either a white or a metallic lustre, are called the tapetum. The smallest portion of light entering from it is reflected as by a concave mirror; and hence it is that the eyes of animals provided with this structure are luminous in a very faint light.

These experiments and observations show that the shining of the eyes of the cat does not arise from a phosphoric light, but only from a reflected light; that consequently it is not an effect of the will of the animal, or of violent passions; that their shining does not appear in absolute darkness; and that it cannot enable the animal to move securely in the dark.

It has been proved by experiment that there exists a set of ays of light of far higher refrangibility than those seen in the ordinary Newtonian spectrum. Mr. Hunt considers it probable that these highly refrangible rays, although under ordinary circumstances invisible to the human eye, may be adapted to produce the necessary degree of excitement upon which vision depends in the optic nerves of the night-roaming animals. The at, the owl, and the cat may see in the gloom of the night by the aid of rays which are invisible to, or inactive on, the eyes of man or those animals which require the light of day for perfect vision.

Astronomy.

THE GREAT TRUTHS OF ASTRONOMY.

The difficulty of understanding these marvellous truths has been glanced at by an old divine (see *Things not generally Known*, p. 1); but the rarity of their full comprehension by those unskilled in mathematical science is more powerfully urged by Lord Brougham in these cogent terms:

> Satisfying himself of the laws which regulate the mutual actions of the planetary bodies, the mathematician can convince himself of a truth yet more sublime than Newton's discovery of gravitation, though flowing from it; and must yield his assent to the marvellous position, that all the irregularities occasioned in the system of the universe by the mutual attraction of its members are periodical, and subject to an eternal law, which prevents them from ever exceeding a stated amount, and secures through all time the balanced structure of a universe composed of bodies whose mighty bulk and prodigious swiftness of motion mock the utmost efforts of the human imagination. All these truths are to tho skilful mathematician as thoroughly known, and their evidence is as clear, as the simplest proposition of arithmetic to common understandings. But how few are those who thus know and comprehend them! Of all the millions that thoroughly believe these truths, certainly not a thousand individuals are capable of following even any considerable portion of the demonstrations upon which they rest; and probably not a hundred now living have ever gone through the whole steps of these demonstrations.—*Dissertations on Subjects of Science connected with Natural Theology,* vol. ii.

Sir David Brewster thus impressively illustrates the same subject:

> Minds fitted and prepared for this species of inquiry are capable of appreciating the great variety of evidence by which the truths of the planetary system are established; but thousands of individuals, and many who are highly distinguished in other branches of knowledge, are incapable of understanding such researches, and view with a sceptical eye the great and irrefragable truths of astronomy.
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> That the sun is stationary in the centre of our system; that the earth moves round the sun, and round its own axis; that the diameter of the earth is 8000 miles, and that of the sun *one hundred and ten times as great;* that the earth's orbit is 190,000,000 of miles in breadth; and that if this immense space were filled with light, it would appear only like a luminous point at the nearest fixed star,—are positions absolutely unintelligible and incredible to all who have not carefully studied the subject. To millions of our species, then, the great Book of Nature is absolutely sealed; though it is in the power of all to unfold its pages, and to peruse those glowing passages which proclaim the power and wisdom of its Author.

ASTRONOMY AND DATES ON MONUMENTS.

Astronomy is a useful aid in discovering the Dates of ancient Monuments. Thus, on the ceiling of a portico among the ruins of Tentyris are the twelve signs of the Zodiac, placed according to the apparent motion of the sun. According to this Zodiac, the summer solstice is in Leo; from which it is easy to compute, by the precession of the equinoxes of $50''{\cdot}1$ annually, that the Zodiac of Tentyris must have been made 4000 years ago.

Mrs. Somerville relates that she once witnessed the ascertainment of the date of a Papyrus by means of astronomy. The manuscript was found in Egypt, in a mummy-case; and its antiquity was determined by the configuration of the heavens at the time of its construction. It proved to be a horoscope of the time of Ptolemy.

"THE CRYSTAL VAULT OF HEAVEN."

This poetic designation dates back as far as the early period of Anaximenes; but the first clearly defined signification of the idea on which the term is based occurs in Empedocles. This philosopher regarded the heaven of the fixed stars as a solid mass, formed from the ether which had been rendered crystalline by the action of fire.

In the Middle Ages, the fathers of the Church believed the firmament to consist of from seven to ten glassy strata, incasing each other like the different coatings of an onion. This supposition still keeps its ground in some of the monasteries of southern Europe, where Humboldt was greatly surprised to hear a venerable prelate express an opinion in reference to the fall of aerolites at Aigle, that the bodies we called meteoric stones with vitrified crusts were not portions of the fallen stone itself, but simply fragments of the crystal vault shattered by it in its fall.

Empedocles maintained that the fixed stars were riveted to the crystal heavens; but that the planets were free and unconstrained. It is difficult to conceive how, according to Plato in the *Timæus*, the fixed stars, riveted as they are to solid spheres, could rotate independently.

Among the ancient views, it may be mentioned that the equal distance at which the stars remained, while the whole vault of heaven seemed to move from east to west, had led to the idea of a firmament and a solid crystal sphere, in which Anaximenes (who was probably not much later than Pythagoras) had conjectured that the stars were riveted like nails.

MUSIC OF THE SPHERES.

The Pythagoreans, in applying their theory of numbers to the geometrical consideration of the five regular bodies, to the musical intervals of tone which determine a word and form different kinds of sounds, extended it even to the system of the universe itself; supposing that the moving, and, as it were, vibrating planets, exciting sound-waves, must produce a *spheral music*, according to the harmonic relations of their intervals of space. "This music," they add, "would be perceived by the human ear, if it was not rendered insensible by extreme familiarity, as it is perpetual, and men are accustomed to it from childhood."

The Pythagoreans affirm, in order to justify the reality of the tones produced by the revolution of the spheres, that hearing takes place only where there is an alternation of sound and silence. The inaudibility of the spheral music is also accounted for by its overpowering the senses. Aristotle himself calls the Pythagorean tone-myth pleasing and ingenious, but untrue.

Plato attempted to illustrate the tones of the universe in an agreeable picture, by attributing to each of the planetary spheres a syren, who, supported by the stern daughters of Necessity, the three Fates, maintain the eternal revolution of the world's axis. Mention is constantly made of the harmony of the spheres, though generally reproachfully, throughout the writings of Christian antiquity and the Middle Ages, from Basil the Great to Thomas Aquinas and Petrus Alliacus.

At the close of the sixteenth century, Kepler revived these musical ideas, and sought to trace out the analogies between the relations of tone and the distances of the planets; and Tycho Brahe was of opinion that the revolving conical bodies were capable of vibrating the celestial air (what we now call "resisting medium") so as to produce tones. Yet Kepler, although he had talked of Venus and the Earth sounding sharp in aphelion and flat in perihelion, and the highest tone of Jupiter and that of Venus coinciding in flat accord, positively declared there to be "no such things as sounds among the heavenly bodies, nor is their motion so turbulent as to elicit noise from the attrition of the celestial air." (See *Things not generally Known*, p. 44.)

"MORE WORLDS THAN ONE."

Although this opinion was maintained incidentally by various writers both on astronomy* and natural religion, yet M.

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* The original idea is even attributed to Copernicus. M. Blundevile, in his *Treatise on Cosmography*, 1594, has the following passage, perhaps the most distinct recognition of authority in our language: "How prooue (prove) you that there is but one world? By the authoritie of Aristotle, who saieth that if there were any other world out of this, then the earth of that world would mooue (move) towards the centre of this world," &c.

Sir Isaac Newton, in a conversation with Conduitt, said he took "all the planets to be composed of the same matter with the earth, viz. earth, water, and stone, but variously concocted."

Fontenelle was the first individual who wrote a treatise on the *Plurality of Worlds*, which appeared in 1685, the year before the publication of Newton's *Principia.* Fontenelle's work consists of five chapters: 1. The earth is a planet which turns round its axis, and also round the sun. 2. The moon is a habitable world. 3. Particulars concerning the world in the moon, and that the other planets are also inhabited. 4. Particulars of the worlds of Venus, Mercury, Mars, Jupiter, and Saturn. 5. The fixed stars are as many suns, each of which illuminates a world. In a future edition, 1719, Fontenelle added, 6. New thoughts which confirm those in the preceding conversations, and the latest discoveries which have been made in the heavens. The next work on the subject was the *Theory of the Universe, or Conjectures concerning the Celestial Bodies and their Inhabitants,* 1698, by Christian Huygens, the contemporary of Newton.

The doctrine is maintained by almost all the distinguished astronomers and writers who have flourished since the true figure of the earth was determined. Giordano Bruna of Nola, Kepler, and Tycho Brahe, believed in it; and Cardinal Cusa and Bruno, before the discovery of binary systems among the stars, believed also that the stars were inhabited. Sir Isaac Newton likewise adopted the belief; and Dr. Bentley, Master of Trinity College, Cambridge, in his eighth sermon on the Confutation of Atheism from the origin and frame of the world, has ably maintained the same doctrine. In our own day we may number among its supporters the distinguished names of the Marquis de la Place, Sir William and Sir John Herschel, Dr. Chalmers, Isaac Taylor, and M. Arago. Dr. Chalmers maintains the doctrine in his *Astronomical Discourses*, which one Alexander Maxwell (who did not believe in the grand truths of astronomy) attempted to controvert, in 1820, in a chapter of a volume entitled *Plurality of Worlds.*

Next appeared *Of a Plurality of Worlds*, attributed to the Rev. Dr. Whewell, Master of Trinity College, Cambridge; urging the theological not less than the scientific reasons for believing in the old tradition of a single world, and maintaining that "the earth is really the largest planetary body in the solar system,—its domestic hearth, and the only world in the universe." "I do not pretend," says Dr. Whewell, "to disprove the plurality of worlds; but I ask in vain for any argument which makes the doctrine probable." "It is too remote from knowledge to be either proved or disproved." Sir David Brewster has replied to Dr. Whewell's Essay, in *More Worlds than One, the Creed of the Philosopher and the Hope of the Christian*, emphatically maintaining that analogy strongly countenances the idea of all the solar planets, if not all worlds in the universe, being peopled with creatures not dissimilar in being and nature to the inhabitants of the earth. This view is supported in *Scientific Certainties of Planetary Life*, by T. C. Simon, who well treats one point of the argument—that mere distance of the planets from the central sun does not determine the condition as to light and heat, but that the density of the ethereal medium enters largely into the calculation. Mr. Simon's general conclusion is, that "neither on account of deficient or excessive heat, nor with regard to the density of the materials, nor with regard to the force of gravity on the surface, is there the slightest pretext for supposing that all the planets of our system are not inhabited by intellectual creatures with animal bodies like ourselves,—moral beings, who know and love their great Maker, and who wait, like the rest of His creation, upon His providence and upon His care." One of the leading points of Dr. Whewell's Essay is, that we should not elevate the conjectures of analogy into the rank of scientific certainties; and that "the force of all the presumptions drawn from physical reasoning for the opinion of planets and stars being either inhabited or uninhabited is so small, that the belief of all thoughtful persons on this subject will be determined by moral, metaphysical, and theological considerations."

WORLDS TO COME—ABODES OF THE BLEST.

Sir David Brewster, in his eloquent advocacy of the doctrine of "more worlds than one," thus argues for their peopling:

> Man, in his future state of existence, is to consist, as at present, of a spiritual nature residing in a corporeal frame. He must live, therefore, upon a material planet, subject to all the laws of matter, and performing functions for which a material body is indispensable. We must consequently find for the race of Adam, if not races that may have preceded him, a material home upon which they may reside, or by which they may travel, by means unknown to us, to other localities in the universe. At the present hour, the inhabitants of the earth are nearly *a thousand millions;* and by whatever process we may compute the numbers that have existed before the present generation, and estimate those that are yet to inherit the earth, we shall obtain a population which the habitable parts of our globe could not possibly accommodate. If there is not room, then, on our earth for the millions of millions of beings who have lived and died upon its surface, and who may yet live and die during the period fixed for its occupation by man, we can scarcely doubt that their future abode must be on some of the primary or secondary planets of the solar system, whose inhabitants have ceased to exist like those on the earth, or upon planets in our own or in other systems which have been in a state of preparation, as our earth was, for the advent of intellectual life.

"GAUGING THE HEAVENS."

Sir William Herschel, in 1785, conceived the happy idea of counting the number of stars which passed at different heights and in various directions over the field of view, of fifteen minutes in diameter, of his twenty-feet reflecting telescope. The field of view each time embraced only $\frac{1}{833000}$th of the whole heavens; and it would therefore require, according to Struve, eighty-three years to gauge the whole sphere by a similar process.

VELOCITY OF THE SOLAR SYSTEM.

M. F. W. G. Struve gives as the splendid result of the united studies of MM. Argelander, O. Struve, and Peters, grounded on observations made at the three Russian observatories of Dorpat, Abo, and Pulkowa, "that the velocity of the motion of the solar system in space is such that the sun, with all the bodies which depend upon it, advances annually towards the constellation Hercules* 1·623 times the radius of the earth's orbit, or 33,550,000 geographical miles. The possible error of this last number amounts to 1,733,000 geographical miles, or to a *seventh* of the whole value. We may, then, wager 400,000 to 1 that the sun has a proper progressive motion, and 1 to 1 that it is comprised between the limits of thirty-eight and twenty-nine millions of geographical miles."

That is, taking 95,000,000 of English miles as the mean radius of the Earth's orbit, we have 95 + 1·623 = 154·185 millions of miles; and consequently,

	English Miles.
The velocity of the Solar System .	154,185,000 in the year.
,, ,, ...	422,424 in a day.
,, ,, ...	17,601 in an hour.
,, ,, ...	293 in a minute.
,, ,, ...	57 in a second.

The Sun and all his planets, primary and secondary, are therefore now in rapid motion round an invisible focus. To that now dark and mysterious centre, from which no ray, however feeble, shines, we may in another age point our telescopes, detecting perchance the great luminary which controls our system and bounds its path: into that vast orbit man, during the whole cycle of his race, may never be allowed to round.—*North-British Review,* No. 16.

NATURE OF THE SUN.

M. Arago has found, by experiments with the polariscope, that the light of gaseous bodies is natural light when it issues from the burning surface; although this circumstance does not prevent its subsequent complete polarisation, if subjected to suitable reflections or refractions. Hence we obtain *a most simple method of discovering the nature of the sun* at a distance of forty millions of leagues. For if the light emanating from the margin of the sun, and radiating from the solar substance *at an acute angle,* reach us without having experienced any sensible reflections or refractions in its passage to the earth, and if it offer traces of polarisation, the sun must be *a solid or a liquid body.* But if, on the contrary, the light emanating from the sun's margin give no indications of polarisation, the *incandescent* portion of the sun must be *gaseous.* It is by means of such a methodical sequence of observations that we may acquire exact ideas regarding the physical constitution of the sun.—*Note to Humboldt's Cosmos,* vol. iii.

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* Sir William Herschel ascertained that our solar system is advancing towards the constellation Hercules, or more accurately to a point in space whose right ascension is 245° 52′ 30″, and north polar distance 40° 22′; and that the quantity of this motion is such, that to an astronomer placed in Sirius, our sun would appear to describe an arc of little more than *a second* every year.—*North-British Review,* No. 3.

STRUCTURE OF THE LUMINOUS DISC OF THE SUN.

The extraordinary structure of the *fully luminous* Disc of the Sun, as seen through Sir James South's great achromatic, in a drawing made by Mr. Gwilt, resembles compressed curd, or white almond-soap, or a mass of asbestos fibres, lying in a *quaquaversus* direction, and compressed into a solid mass. There can be no illusion in this phenomenon; it is seen by every person with good vision, and on every part of the sun's luminous surface or envelope, which is thus shown to be not a *flame,* but a soft solid or thick fluid, maintained in an incandescent state by subjacent heat, capable of being disturbed by differences of temperature, and broken up as we see it when the sun is covered with spots or openings in the luminous matter.—*North-British Review,* No. 16.

Copernicus named the sun the lantern of the world (*lucerna mundi*); and Theon of Smyrna called it the heart of the universe. The mass of the sun is, according to Encke's calculation of Sabine's pendulum formula, 359,551 times that of the earth, or 355,499 times that of the earth and moon together; whence the density of the sun is only about ¼ (or more accurately 0·252) that of the earth. The volume of the sun is 600 times greater, and its mass, according to Galle, 738 times greater, than that of all the planets combined. It may assist the mind in conceiving a sensuous image of the magnitude of the sun, if we remember that if the solar sphere were entirely hollowed out, and the earth placed in its centre, there would still be room enough for the moon to describe its orbit, even if the radius of the latter were increased 160,000 geographical miles. A railway-engine, moving at the rate of thirty miles an hour, would require 360 years to travel from the earth to the sun. The diameter of the sun is rather more than one hundred and eleven times the diameter of the earth. Therefore the volume or bulk of the sun must be nearly *one million four hundred thousand* times that of the earth. Lastly, if all the bodies composing the solar system were formed into one globe, it would be only about the five-hundredth part of the size of the sun.

GREAT SIZE OF THE SUN ON THE HORIZON EXPLAINED.

The dilated size (generally) of the Sun or Moon, when seen near the horizon, beyond what they appear to have when high up in the sky, has nothing to do with refraction. It is an illusion of the judgment, arising from the terrestrial objects interposed, or placed in close comparison with them. In that situation we view and judge of them as we do of terrestrial objects —in detail, and with an acquired attention to parts. Aloft we have no association to guide us, and their insulation in the expanse of the sky leads us rather to undervalue than to overrate their apparent magnitudes. Actual measurement with a proper instrument corrects our error, without, however, dispelling our illusion. By this we learn that the sun, when just on the horizon, subtends at our eyes almost exactly the same, and the moon a materially *less*, angle than when seen at a greater altitude in the sky, owing to its greater distance from us in the former situation, as compared with the latter.—*Sir John Herschel's Outlines.*

TRANSLATORY MOTION OF THE SUN.

This phenomenon is the progressive motion of the centre of gravity of the whole solar system in universal space. Its velocity, according to Bessel, is probably four millions of miles daily, in a *relative* velocity to that of 61 Cygni of at least 3,336,000 miles, or more than double the velocity of the revolution of the earth in her orbit round the sun. This change of the entire solar system would remain unknown to us, if the admirable exactness of our astronomical instruments of measurement, and the advancement recently made in the art of observing, did not cause our progress towards remote stars to be perceptible, like an approximation to the objects of a distant shore in apparent motion. The proper motion of the star 61 Cygni, for instance, is so considerable, that it has amounted to a whole degree in the course of 700 years.—*Humboldt's Cosmos*, vol. i.

THE SUN'S LIGHT COMPARED WITH TERRESTRIAL LIGHTS.

Mr. Ponton has by means of a simple monochromatic photometer ascertained that a small surface, illuminated by mean solar light, is 444 times brighter than when it is illuminated by a moderator lamp, and 1560 times brighter than when it is illuminated by a wax-candle (short six in the lb.)—the artificial light being in both instances placed at two inches' distance from the illuminated surface. And three electric lights, each equal to 520 wax-candles, will render a small surface as bright as when it is illuminated by mean sunshine.

It is thence inferred, that a stratum occupying the entire surface of the sphere of which the earth's distance from the sun is the radius, and consisting of three layers of flame, each $\frac{1}{1000}$th of an inch in thickness, each possessing a brightness equal to that of such an electric light, and all three embraced within a thickness of $\frac{1}{40}$th of an inch, would give an amount of illumination equal in quantity and intensity to that of the sun at the distance of 95 millions of miles from his centre.

And were such a stratum transferred to the surface of the sun, where it would occupy 46,275 times less area, its thickness would be increased to 94 feet, and it would embrace 138,825 layers of flame, equal in brightness to the electric light; but the same effect might be produced by a stratum about nine miles in thickness, embracing 72 millions of layers, each having only a brightness equal to that of a wax-candle.*

ACTINIC POWER OF THE SUN.

Mr. J. J. Waterston, in 1857, made at Bombay some experiments on the photographic power of the sun's direct light, to obtain data in an inquiry as to the possibility of measuring the diameter of the sun to a very minute fraction of a second, by combining photography with the principle of the electric telegraph; the first to measure the element space, the latter the element time. The result is that about $\frac{1}{20000}$th of a second is sufficient exposure to the direct light of the sun to obtain a distinct mark on a sensitive collodion plate, when developed by the usual processes; and the duration of the sun's full action on any one point is about $\frac{1}{9000}$th of a second.

M. Schatt, a young painter of Berlin, after 1500 experiments, succeeded in establishing a scale of all the shades of black which the action of the sun produces on photographic paper; so that by comparing the shade obtained at any given moment on a certain paper with that indicated on the scale, the exact force of the sun's light may be determined.

HEATING POWER OF THE SUN.

All moving power has its origin in the rays of the sun. While Stephenson's iron tubular railway-bridge over the Menai Straits, 400 feet long, bends but half an inch under the heaviest pressure of a train, it will bend up an inch and a half from its usual horizontal line when the sun shines on it for some hours. The Bunker-Hill monument, near Boston, U.S., is higher in the evening than in the morning of a sunny day; the little sunbeams enter the pores of the stone like so many wedges, lifting it up.

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* See M. Arago's researches upon this interesting subject, in *Things not generally Known*, p. 4.

In winter, the Earth is nearer the Sun by about $\frac{1}{30}$ than in summer; but the rays strike the northern hemisphere more obliquely in winter than the other half year.

M. Pouillet has estimated, with singular ingenuity, from a series of observations made by himself, that the whole quantity of heat which the Earth receives annually from the Sun is such as would be sufficient to melt a stratum of ice covering the entire globe forty-six feet deep.

By the action of the sun's rays upon the earth, vegetables, animals, and man, are in their turn supported; the rays become likewise, as it were, a store of heat, and "the sources of those great deposits of dynamical efficiency which are laid up for human use in our coal strata" (*Herschel*).

A remarkable instance of the power of the sun's rays is recorded at Stonehouse Point, Devon, in the year 1828. To lay the foundation of a sea-wall the workmen had to descend in a diving-bell, which was fitted with convex glasses in the upper part, by which, on several occasions in clear weather, the sun's rays were so concentrated as to burn the labourers' clothes when opposed to the focal point, and this when the bell was twenty-five feet under the surface of the water!

CAUSE OF DARK COLOUR OF THE SKIN.

Darkness of complexion has been attributed to the sun's power from the age of Solomon to this day,—"Look not upon me, because I am black, because the sun hath looked upon me:" and there cannot be a doubt that, to a certain degree, the opinion is well founded. The invisible rays in the solar beams, which change vegetable colour, and have been employed with such remarkable effect in the daguerreotype, act upon every substance on which they fall, producing mysterious and wonderful changes in their molecular state, man not excepted.—*Mrs. Somerville.*

EXTREME SOLAR HEAT.

The fluctuation in the sun's direct heating power amounts to $\frac{1}{15}$th, which is too considerable a fraction of the whole intensity not to aggravate in a serious degree the sufferings of those who are exposed to it in thirsty deserts without shelter. The amount of these sufferings, in the interior of Australia for instance, are of the most frightful kind, and would seem far to exceed what have ever been undergone by travellers in the northern deserts of Africa. Thus Captain Sturt, in his account of his Australian exploration, says: "The ground was almost a molten surface; and if a match accidentally fell upon it, it immediately ignited." Sir John Herschel has observed the temperature of the surface soil in South Africa as high as 159° Fahrenheit. An ordinary lucifer-match does not ignite when simply pressed upon a smooth surface at 212°; but *in the act of withdrawing it* it takes fire, and the slightest friction upon such a surface of course ignites it.

HOW DR. WOLLASTON COMPARED THE LIGHT OF THE SUN AND THE FIXED STARS.

In order to compare the Light of the Sun with that of a Star, Dr. Wollaston took as an intermediate object of comparison the light of a candle reflected from a bulb about a quarter of an inch in diameter, filled with quicksilver; and seen by one eye through a lens of two inches focus, at the same time that the star on the sun's image, *placed at a proper distance*, was viewed by the other eye through a telescope. The mean of various trials seemed to show that the light of Sirius is equal to that of the sun seen in a glass bulb $\frac{1}{10}$th of an inch in diameter, at the distance of 210 feet; or that they are in the proportion of one to ten thousand millions: but as nearly one half of this light is lost by reflection, the real proportion between the light from Sirius and the sun is not greater than that of one to twenty thousand millions.

"THE SUN DARKENED."

Humboldt selects the following example from historical records as to the occurrence of a sudden decrease in the light of the Sun:

> A.D. 33, the year of the Crucifixion. "Now from the sixth hour there was darkness over all the land till the ninth hour" (*St. Matthew* xxvii. 45). According to *St. Luke* (xxiii. 45), "the sun was darkened." In order to explain and corroborate these narrations, Eusebius brings forward an eclipse of the sun in the 202d Olympiad, which had been noticed by the chronicler Phlegon of Tralles (*Ideler, Handbuch der Mathem. Chronologie,* Bd. ii. p. 417). Wurn, however, has shown that the eclipse which occurred during this Olympiad, and was visible over the whole of Asia Minor, must have happened as early as the 24th of November 29 A.D. The day of the Crucifixion corresponded with the Jewish Passover (*Ideler,* Bd. i. pp. 515-520), on the 14th of the month Nisan, and the Passover was always celebrated at the time of the *full moon.* The sun cannot therefore have been darkened for three hours by the moon. The Jesuit Scheiner thinks the decrease in the light might be ascribed to the occurrence of large sun-spots.

THE SUN AND TERRESTRIAL MAGNETISM.

The important influence exerted by the Sun's body, as a mass, upon Terrestrial Magnetism, is confirmed by Sabine in the ingenious observation, that the period at which the intensity of the magnetic force is greatest, and the direction of the needle most near to the vertical line, falls in both hemispheres between the months of October and February; that is to say, precisely at the time when the earth is nearest to the sun, and moves in its orbit with the greatest velocity.

IS THE HEAT OF THE SUN DECREASING?

The Heat of the Sun is dissipated and lost by radiation, and must be progressively diminished unless its thermal energy be supplied. According to the measurements of M. Pouillet, the quantity of heat given out by the sun in a year is equal to that which would be produced by the combustion of a stratum of coal seventeen miles in thickness; and if the sun's capacity for heat be assumed equal to that of water, and the heat be supposed drawn uniformly from its entire mass, its temperature would thereby undergo a diminution of 20·4° Fahr. annually. On the other hand, there is a vast store of force in our system capable of conversion into heat. If, as is indicated by the small density of the sun, and by other circumstances, that body has not yet reached the condition of incompressibility, we have in the future approximation of its parts a fund of heat, probably quite large enough to supply the wants of the human family to the end of its sojourn here. It has been calculated that an amount of condensation which would diminish he diameter of the sun by only the ten-thousandth part, would suffice to restore the heat emitted in 2000 years.

UNIVERSAL SUN-DIAL.

Mr. Sharp, of Dublin, exhibited to the British Association n 1849 a Dial, consisting of a cylinder set to the day of the month, and then elevated to the latitude. A thin plane of metal, in the direction of its axis, is then turned by a milled head below it till the shadow is a minimum, when a dial on he top shows the hours by one hand, and the minutes by another, to the precision of about three minutes.

LENGTH OF DAYS AT THE POLES.

During the summer, in the northern hemisphere, places near the North Pole are in *continual sunlight*—the sun never ets to them; while during that time places near the South Pole never see the sun. When it is summer in the southern emisphere, and the sun shines on the South Pole without etting, the North Pole is entirely deprived of his light. In-eed, at the Poles there is but *one day and one night;* for the sun shines for six months together on one Pole, and the other six months on the other Pole.

HOW THE DISTANCE OF THE SUN IS ASCERTAINED BY THE YARD-MEASURE.

Professor Airy, in his *Six Lectures on Astronomy*, gives a masterly analysis of a problem of considerable intricacy, viz. the determination of the parallax of the sun, and consequently of his distance, by observations of the transit of Venus, the connecting link between measures upon the earth's surface and the dimensions of our system. The further step of investigating the parallax, and consequently the distance of the fixed stars (where that is practicable), is also elucidated; and the author, with evident satisfaction, thus sums up the several steps:

> By means of a yard-measure, a base-line in a survey was measured; from this, by the triangulations and computations of a survey, an arc of meridian on the earth was measured; from this, with proper observations with the zenith sector, the surveys being also repeated on different parts of the earth, the earth's form and dimensions were ascertained; from these, and a previous independent knowledge of the proportions of the distances of the earth and other planets from the sun, with observations of the transit of Venus, the sun's distance is determined; and from this, with observations leading to the parallax of the stars, the distance of the stars is determined. And *every step in the process can be distinctly referred to its basis, that is, the yard-measure.*

HOW THE TIDES ARE PRODUCED BY THE SUN AND MOON.

Each of these bodies excites, by its attraction upon the waters of the sea, two gigantic waves, which flow in the same direction round the world as the attracting bodies themselves apparently do. The two waves of the moon, on account of her greater nearness, are about 3½ times as large as those excited by the sun. One of these waves has its crest on the quarter of the earth's surface which is turned towards the moon; the other is at the opposite side. Both these quarters possess the flow of the tide, while the regions which lie between have the ebb. Although in the open sea the height of the tide amounts to only about three feet, and only in certain narrow channels, where the moving water is squeezed together, rises to thirty feet, the might of the phenomenon is nevertheless manifest from the calculation of Bessel, according to which a quarter of the earth covered by the sea possesses during the flow of the tide about 25,000 cubic miles of water more than during the ebb; and that, therefore, such a mass of water must in 6¼ hours flow from one quarter of the earth to the other.—*Professor Helmholtz.*

SPOTS ON THE SUN.

Sir John Herschel describes these phenomena, when watched from day to day, or even from hour to hour, as appearing to enlarge or contract, to change their forms, and at length disappear altogether, or to break out anew in parts of the surface where none were before. Occasionally they break up or divide into two or more. The scale on which their movements takes place is immense. A single second of angular measure, as seen from the earth, corresponds on the sun's disc to 461 miles; and a circle of this diameter (containing therefore nearly 167,000 square miles) is the least space which can be distinctly discerned on the sun as a *visible area.* Spots have been observed, however, whose linear diameter has been upwards of 45,000 miles; and even, if some records are to be trusted, of very much greater extent. That such a spot should close up in six weeks time (for they seldom last much longer), its borders must approach at the rate of more than 1000 miles a-day.

The same astronomer saw at the Cape of Good Hope, on the 29th March 1837, a solar spot occupying an area of near *five square minutes,* equal to 3,780,000,000 square miles. "The black centre of the spot of May 25th, 1837 (not the tenth part of the preceding one), would have allowed the globe of our earth to drop through it, leaving a thousand miles clear of contact on all sides of that tremendous gulf." For such an amount of disturbance on the sun's atmosphere, what reason can be assigned?

The Rev. Mr. Dawes has invented a peculiar contrivance, by means of which he has been enabled to scrutinise, under high magnifying power, minute portions of the solar disc. He places a metallic screen, pierced with a very small hole, in the focus of the telescope, where the image of the sun is formed. A small portion only of the image is thus allowed to pass through, so that it may be examined by the eye-piece without inconveniencing the observer by heat or glare. By this arrangement, Mr. Dawes has observed peculiarities in the constitution of the sun's surface which are discernible in no other way.

Before these observations, the dark spots seen on the sun's surface were supposed to be portions of the solid body of the sun, laid bare to our view by those immense fluctuations in the luminous regions of its atmosphere to which it appears to be subject. It now appears that these dark portions are only an additional and inferior stratum of a very feebly luminous or illuminated portion of the sun's atmosphere. This again in its turn Mr. Dawes has frequently seen pierced with a smaller and usually much more rounded aperture, which would seem at last to afford a view of the real solar surface of most intense blackness.

M. Schwabe, of Dessau, has discovered that the abundance or paucity of spots displayed by the sun's surface is subject to a law of periodicity. This has been confirmed by M. Wolf, of Berne, who shows that the period of these changes, from minimum to minimum, is 11 years and 11-hundredths of a year, being exactly at the rate of nine periods per century, the last year of each century being a year of minimum. It is strongly corroborative of the correctness both of M. Wolf's period and also of the periodicity itself, that of all the instances of the appearance of spots on the sun recorded in history, even before the invention of the telescope, or of remarkable deficiencies in the sun's light, of which there are great numbers, only two are found to deviate as much as two years from M. Wolf's epochs. Sir William Herschel observed that the presence or absence of spots had an influence on the temperature of the seasons; his observations have been fully confirmed by M. Wolf. And, from an examination of the chronicles of Zurich from A.D. 1000 to A.D. 1800, he has come to the conclusion "that years rich in solar spots are in general drier and more fruitful than those of an opposite character; while the latter are wetter and more stormy than the former."

The most extraordinary fact, however, in connection with the spots on the sun's surface, is the singular coincidence of their periods with those great disturbances in the magnetic system of the earth to which the epithet of "magnetic storms" has been affixed.

These disturbances, during which the magnetic needle is greatly and universally agitated (not in a particular limited locality, but at one and the same instant of time over whole continents, or even over the whole earth), are found, so far as observation has hitherto extended, to maintain a parallel, both in respect of their frequency of occurrence and intensity in successive years, with the abundance and magnitude of the spots in the same years, too close to be regarded as fortuitous. The coincidence of the epochs of maxima and minima in the two series of phenomena amounts, indeed, to identity; a fact evidently of most important significance, but which neither astronomical nor magnetic science is yet sufficiently advanced to interpret.—*Herschel's Outlines.*

The signification and connection of the above varying phenomena (Humboldt maintains) can never be manifested in their entire importance until an uninterrupted series of representations of the sun's spots can be obtained by the aid of mechanical clock-work and photographic apparatus, as the result of prolonged observations during the many months of serene weather enjoyed in a tropical climate.

M. Schwabe has thus distinguished himself as an indefatigable observer of the sun's spots, for his researches received the Royal Astronomical Society's Medal in 1857. "For thirty years," said the President at the presentation, "never has the sun exhibited his disc above the horizon of Dessau without being confronted by Schwabe's imperturbable telescope; and that appears to have happened on an average about 300 days a-year. So, supposing that he had observed but once a-day, he has made 9000 observations, in the course of which he discovered about 4700 groups. This is, I believe, an instance of devoted persistence unsurpassed in the annals of astronomy. The energy of one man has revealed a phenomenon that had eluded the suspicion of astronomers for 200 years."

HAS THE MOON AN ATMOSPHERE?

The Moon possesses neither Sea nor Atmosphere of appreciable extent. Still, as a negative, in such case, is relative only to the capabilities of the instruments employed, the search for the indications of a lunar atmosphere has been renewed with fresh augmentation of telescopic power. Of such indications, the most delicate, perhaps, are those afforded by the occultation of a planet by the moon. The occultation of Jupiter, which took place on January 2, 1857, was observed with this reference, and is said to have exhibited no *hesitation*, or change of form or brightness, such as would be produced by the refraction or absorption of an atmosphere. As respects the sea, if water existed on the moon's surface, the sun's light reflected from it should be completely polarised at a certain elongation of the moon from the sun; and no traces of such light have been observed.

MM. Baer and Maedler conclude that the moon is not entirely without an atmosphere, but, owing to the smallness of her mass, she is incapacitated from holding an extensive covering of gas; and they add, "it is possible that this weak envelope may sometimes, through local causes, in some measure dim or condense itself." But if any atmosphere exists on our satellite, it must be, as Laplace says, more attenuated than what is termed a vacuum in an air-pump.

Mr. Hopkins thinks that if there be any lunar atmosphere, it must be very rare in comparison with the terrestrial atmosphere, and inappreciable to the kind of observation by which it has been tested; yet the absence of any refraction of the light of the stars during occultation is a very refined test. Mr. Nasmyth observes that "the sudden disappearance of the stars behind the moon, without any change or diminution of her brilliancy, is one of the most beautiful phenomena that can be witnessed."

Sir John Herschel observes: The fact of the moon turning always the same face towards the earth is, in all probability, the result of an elongation of its figure in the direction of a line joining the centres of both the bodies, acting conjointly with a non-coincidence of its centre of gravity with its centre of symmetry.

If to this we add the supposition that the substance of the moon is not homogeneous, and that some considerable preponderance of weight is placed excentrically in it, it will be easily apprehended that the portion of its surface nearer to that heavier portion of its solid content, under all the circumstances of the moon's rotation, will permanently occupy the situation most remote from the earth.

In what regards its assumption of a definite level, air obeys precisely the same hydrostatical laws as water. The lunar atmosphere would rest upon the lunar ocean, and form in its basin a lake of air, whose upper portions at an altitude such as we are now contemplating would be of excessive tenuity, especially should the provision of air be less abundant in proportion than our own. It by no means follows, then, from the absence of visible indications of water or air on this side of the moon, that the other is equally destitute of them, and equally unfitted for maintaining animal or vegetable life. Some slight approach to such a state of things actually obtains on the earth itself. Nearly all the land is collected in one of its hemispheres, and much the larger portion of the sea in the opposite. There is evidently an excess of heavy material vertically beneath the middle of the Pacific; while not very remote from the point of the globe diametrically opposite rises the great tableland of India and the Himalaya chain, on the summits of which the air has not more than a third of the density it has on the sea-level, and from which animated existence is for ever excluded.—*Herschel's Outlines,* 5th edit.

LIGHT OF THE MOON.

The actual illumination of the lunar surface is not much superior to that of weathered sandstone-rock in full sunshine. Sir John Herschel has frequently compared the moon setting behind the gray perpendicular façade of the Table Mountain at the Cape of Good Hope, illuminated by the sun just risen from the opposite quarter of the horizon, when it has been scarcely distinguishable in brightness from the rock in contact with it. The sun and moon being nearly at equal altitudes, and the atmosphere perfectly free from cloud or vapour, its effect is alike on both luminaries.

HEAT OF MOONLIGHT.

M. Zantedeschi has proved, by a long series of experiments in the Botanic Gardens at Venice, Florence, and Padua, that, contrary to the general opinion, the diffused rays of moonlight have an influence upon the organs of plants, as the Sensitive Plant and the *Desmodium gyrans*. The influence was feeble compared with that of the sun; but the action is left beyond further question.

Melloni has proved that the rays of the Moon give out a slight degree of Heat (see *Things not generally Known*, p. 7); and Professor Piazzi Smyth, from a point of the Peak of Teneriffe 8840 feet above the sea-level, has found distinctly perceptible the heat radiated from the moon, which has been so often sought for in vain in a lower region.

SCENERY OF THE MOON.

By means of the telescope, mountain-peaks are distinguished in the ash-gray light of the larger spots and isolated brightly-shining points of the moon, even when the disc is already more than half illuminated. Lambert and Schroter have shown that the extremely variable intensity of the ash-gray light of the moon depends upon the greater or less degree of reflection of the sunlight which falls upon the earth, according as it is reflected from continuous continental masses, full of sandy deserts, grassy steppes, tropical forests, and barren rocky ground, or from large ocean surfaces. Lambert made the remarkable observation (14th of February 1774) of a change of the ash-coloured moonlight into an olive-green colour bordering upon yellow. "The moon, which then stood vertically over the Atlantic Ocean, received upon its right side the green terrestrial light which is reflected towards her when the sky is clear by the forest districts of South America."

Plutarch says distinctly, in his remarkable work *On the Face in the Moon*, that we may suppose the *spots* to be partly deep chasms and valleys, partly mountain-peaks, which cast long shadows, like Mount Athos, whose shadow reaches Lemnos. The spots cover about two-fifths of the whole disc. In a clear atmosphere, and under favourable circumstances in the position of the moon, some of the spots are visible to the naked eye; as the edge of the Apennines, the dark elevated plain Grimaldus, the enclosed *Mare Crisium*, and Tycho, crowded round with numerous mountain ridges and craters.

Professor Alexander remarks, that a map of the eastern hemisphere, taken with the Bay of Bengal in the centre, would bear a striking resemblance to the face of the moon presented to us. The dark portions of the moon he considers to be continental elevations, as shown by measuring the average height of mountains above the dark and the light portions of the moon.

The surface of the moon can be as distinctly seen by a good telescope magnifying 1000 times, as it would be if not more than 250 miles distant.

LIFE IN THE MOON.

A circle of one second in diameter, as seen from the earth, on the surface of the moon contains about a square mile.

Telescopes, therefore, must be greatly improved before we could expect to see signs of inhabitants, as manifested by edifices or changes on the surface of the soil. It should, however, be observed, that owing to the small density of the materials of the moon, and the comparatively feeble gravitation of bodies on her surface, muscular force would there go six times as far in overcoming the weight of materials as on the earth. Owing to the want of air, however, it seems impossible that any form of life analogous to those on earth can subsist there. No appearance indicating vegetation, or the slightest variation of surface which can in our opinion fairly be ascribed to change of season, can any where be discerned.—*Sir John Herschel's Outlines.*

THE MOON SEEN THROUGH LORD ROSSE'S TELESCOPE.

In 1846, the Rev. Dr. Scoresby had the gratification of observing the Moon through the stupendous telescope constructed by Lord Rosse at Parsonstown. It appeared like a globe of molten silver, and every object to the extent of 100 yards was quite visible. Edifices, therefore, of the size of York Minster, or even of the ruins of Whitby Abbey, might be easily perceived, if they had existed. But there was no appearance of any thing of that nature; neither was there any indication of the existence of water, or of an atmosphere. There were a great number of extinct volcanoes, several miles in breadth; through one of them there was a line of continuance about 150 miles in length, which ran in a straight direction, like a railway. The general appearance, however, was like one vast ruin of nature; and many of the pieces of rock driven out of the volcanoes appeared to lie at various distances.

MOUNTAINS IN THE MOON.

By the aid of telescopes, we discern irregularities in the surface of the moon which can be no other than mountains and valleys,—for this plain reason, that we see the shadows cast by the former in the exact proportion as to length which they ought to have when we take into account the inclinations of the sun's rays to that part of the moon's surface on which they stand. From micrometrical measurements of the lengths of the shadows of the more conspicuous mountains, Messrs. Baer and Maedler have given a list of heights for no less than 1095 lunar mountains, among which occur all degrees of elevation up to 22,823 British feet, or about 1400 feet higher than Chimborazo in the Andes.

If Chimborazo were as high in proportion to the earth's diameter as a mountain in the moon known by the name of

Newton is to the moon's diameter, its peak would be more than sixteen miles high.

Arago calls to mind, that with a 6000-fold magnifying power, which nevertheless could not be applied to the moon with proportionate results, the mountains upon the moon would appear to us just as Mont Blanc does to the naked eye when seen from the Lake of Geneva.

We sometimes observe more than half the surface of the moon, the eastern and northern edges being more visible at one time, and the western or southern at another. By means of this libration we are enabled to see the annular mountain Malapert (which occasionally conceals the moon's south pole), the arctic landscape round the crater of Gioja, and the large gray plane near Endymion, which conceals in superficial extent the *mare vaporum*.

Three-sevenths of the moon are entirely concealed from our observation; and must always remain so, unless some new and unexpected disturbing causes come into play.—*Humboldt.*

The first object to which Galileo directed his telescope was the mountainous parts of the moon, when he showed how their summits might be measured: he found in the moon some circular districts surrounded on all sides by mountains similar to the form of Bohemia. The measurements of the mountains were made by the method of the tangents of the solar ray. Galileo, as Helvetius did still later, measured the distance of the summit of the mountains from the boundary of the illuminated portion at the moment when the mountain summit was first struck by the solar ray. Humboldt found no observations of the lengths of the shadows of the mountains: the summits were "much higher than the mountains on our earth" The comparison is remarkable, since, according to Riccioli, very exaggerated ideas of the height of our mountains were then entertained. Galileo like all other observers up to the close of the eighteenth century, believed in the existence of many seas and of a lunar atmosphere.

THE MOON AND THE WEATHER.

The only influence of the Moon on the Weather of which we have any decisive evidence is the tendency to disappearance of clouds under the full moon, which Sir John Herschel refers to its heat being much more readily absorbed in traversing transparent media than direct solar heat, and being extinguished in the upper regions of our atmosphere, never reaches the surface of the atmosphere at all.

THE MOON'S ATTRACTION.

Mr. G. P. Bond of Cambridge, by some investigations to ascertain whether the Attraction of the Moon has any effect upon the motion of a pendulum, and consequently upon the rate of a clock, has found the last to be changed to the amount of $\frac{2}{1000}$ of a second daily. At the equator the moon's attraction changes the weight of a body only $\frac{1}{7000000}$ of the whole; yet this force is sufficient to produce the vast phenomena of the tides!

It is no slight evidence of the importance of analysis, that Laplace's perfect theory of tides has enabled us in our astronomical ephemerides to predict the height of spring-tides at the periods of new and full moon, and thus put the inhabitants of the sea on their guard against the increased danger attending the lunar revolutions.

MEASURING THE EARTH BY THE MOON.

As the form of the Earth exerts a powerful influence on the motion of other cosmical bodies, and especially on that of its neighbouring satellite, a more perfect knowledge of the motion of the latter will enable us reciprocally to draw an inference regarding the figure of the earth. Thus, as Laplace ably remarks: "an astronomer, without leaving his observatory, may, by a comparison of lunar theory with true observations, not only be enabled to determine the form and size of the earth, but also its distance from the sun and moon; results that otherwise could only be arrived at by long and arduous expeditions to the most remote parts of both hemispheres." The compression which may be inferred from lunar inequalities affords an advantage not yielded by individual measurements of degrees or experiments with the pendulum, since it gives a mean amount which is referable to the whole planet.—*Humboldt's Cosmos*, vol. i.

The distance of the moon from the earth is about 240,000 miles; and if a railway-carriage were to travel at the rate of 1000 miles a-day, it would be eight months in reaching the moon. But that is nothing compared with the length of time it would occupy a locomotive to reach the sun from the earth: if travelling at the rate of 1000 miles a-day, it would require 260 years to reach it.

CAUSE OF ECLIPSES.

As the Moon is at a very moderate distance from us (astronomically speaking), and is in fact our nearest neighbour, while the sun and stars are in comparison immensely beyond it, it must of necessity happen that at one time or other it must *pass over*, and *occult* or *eclipse*, every star or planet within its zone, and, as seen from the *surface* of the earth, even somewhat beyond it. Nor is the sun itself exempt from being thus hidden whenever any part of the moon's disc, in this her tortuous course, comes to *overlap* any part of the space occupied in the heavens by that luminary. On these occasions is exhibited the most striking and impressive of all the occasional phenomena of astronomy, an *Eclipse of the Sun,* in which a greater or less portion, or even in some conjunctures the whole of its disc, is obscured, and, as it were, obliterated, by the superposition of that of the moon, which appears upon it as a circularly-terminated black spot, producing a temporary diminution of daylight, or even nocturnal darkness, so that the stars appear as if at midnight.—*Sir John Herschel's Outlines.*

VAST NUMBERS IN THE UNIVERSE.

The number of telescopic stars in the Milky Way uninterrupted by any nebulæ is estimated at 18,000,000. To compare this number with something analogous, Humboldt calls attention to the fact, that there are not in the whole heavens more than about 8000 stars, between the first and the sixth magnitudes, visible to the naked eye. The barren astonishment excited by numbers and dimensions in space when not considered with reference to applications engaging the mental and perceptive powers of man, is awakened in both extremes of the universe—in the celestial bodies as in the minutest animalcules. A cubic inch of the polishing slate of Bilin contains, according to Ehrenberg, 40,000 millions of the siliceous shells of Galionellæ.

FOR WHAT PURPOSE WERE THE STARS CREATED?

Surely not (says Sir John Herschel) to illuminate *our* nights, which an additional moon of the thousandth part of the size of our own would do much better; nor to sparkle as a pageant void of meaning and reality, and bewilder us among vain conjectures. Useful, it is true, they are to man as points of exact and permanent reference; but he must have studied astronomy to little purpose, who can suppose man to be the only object of his Creator's care, or who does not see in the vast and wonderful apparatus around us provision for other races of animated beings. The planets derive their light from the sun; but that cannot be the case with the stars. These doubtless, then, are themselves suns; and may perhaps, each in its sphere, be the presiding centre round which other planets, or bodies of which we can form no conception from any analogy offered by our own system, are circulating.*

NUMBER OF STARS.

Various estimates have been hazarded on the Number of Stars throughout the whole heavens visible to us by the aid of our colossal telescopes. Struve assumes for Herschel's 20-feet reflector, that a magnifying power of 180 would give 5,800,000 for the number of stars lying within the zones extending 30° on either side of the equator, and 20,374,000 for the whole heavens. Sir William Herschel conjectured that 18,000,000 of stars in the Milky Way might be seen by his still more powerful 40-feet reflecting telescope.—*Humboldt's Cosmos*, vol. iii.

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* This eloquent advocacy of the doctrine of "More Worlds than One" (referred to at p. 56) is from the author's valuable *Outlines of Astronomy.*

The assumption that the extent of the starry firmament is literally infinite has been made by Dr. Olbers the basis of a conclusion that the celestial spaces are in some slight degree deficient in *transparency;* so that all beyond a certain distance is and must remain for ever unseen, the geometrical progression of the extinction of light far outrunning the effect of any conceivable increase in the power of our telescopes. Were it not so, it is argued that every part of the celestial concave ought to shine with the brightness of the solar disc, since no visual ray could be so directed as not, in some point or other of its infinite length, to encounter such a disc.—*Edinburgh Review*, Jan. 1848.

STARS THAT HAVE DISAPPEARED.

Notwithstanding the great accuracy of the catalogued positions of telescopic fixed stars and of modern star-maps, the certainty of conviction that a star in the heavens has actually disappeared since a certain epoch can only be arrived at with great caution. Errors of actual observation, of reduction, and of the press, often disfigure the very best catalogues. The disappearance of a heavenly body from the place in which it had been before distinctly seen, may be the result of its own motion as much as of any such diminution of its photometric process as would render the waves of light too weak to excite our organs of sight. What we no longer see, is not necessarily annihilated. The idea of destruction or combustion, as applied to disappearing stars, belongs to the age of Tycho Brahe. Even Pliny makes it a question. The apparent eternal cosmical alternation of existence and destruction is not annihilation; it is merely the transition of matter into new forms, into combinations which are subject to new processes. Dark cosmical bodies may by a renewed process of light again become luminous.—*Humboldt's Cosmos*, vol. iii.

THE POLE-STAR FOUR THOUSAND YEARS AGO.

Sir John Herschel, in his *Outlines of Astronomy*, thus shows the changes in the celestial pole in 4000 years:

At the date of the erection of the Pyramid of Gizeh, which precedes the present epoch by nearly 4000 years, the longitudes of all the stars were less by 55° 45′ than at present. Calculating from this datum the place of the pole of the heavens among the stars, it will be found to fall near α Draconis; its distance from that star being 3° 44′ 25″. This being the most conspicuous star in the immediate neighbourhood, was therefore the Pole Star of that epoch. The latitude of Gizeh being just 30° north, and consequently the altitude of the North Pole there also 30°, it follows that the star in question must have had at its lowest culmination at Gizeh an altitude of 25° 15′ 35″. Now it is a remarkable fact, that of the nine pyramids still existing at Gizeh, six (including all the largest) have the narrow passages by which alone they can be entered (all which open out on the northern faces of their respective pyramids) inclined to the horizon downwards at angles the mean of which is 26° 47′. At the bottom of every one of these passages, therefore, the Pole Star must have been visible at its lower culmination; a circumstance which can hardly be supposed to have been unintentional, and was doubtless connected (perhaps superstitiously) with the astronomical observations of that star, of whose proximity to the pole at the epoch of the erection of these wonderful structures we are thus furnished with a monumental record of the most imperishable nature.

THE PLEIADES.

The Pleiades prove that, several thousand years ago even as now, stars of the seventh magnitude were invisible to the naked eye of average visual power. The group consists of seven stars, of which six only, of the third, fourth, and fifth magnitudes, could be readily distinguished. Of these Ovid says (*Fast.* iv. 170):

> "Quæ septem dici, sex tamen esse solent."

Aratus states there were only six stars visible in the Pleiades.

One of the daughters of Atlas, Merope, the only one who was wedded to a mortal, was said to have veiled herself for very shame and to have disappeared. This is probably the star of the seventh magnitude, which we call Celæne; for Hipparchus, in his commentary on Aratus, observes that on clear moonless nights *seven stars* may actually be seen.

The Pleiades were doubtless known to the rudest nations from the earliest times; they are also called the *mariner's stars.* The name is from πλεῖν (*plein*), 'to sail.' The navigation of the Mediterranean lasted from May to the beginning of November, from the early rising to the early setting of the Pleiades. In how many beautiful effusions of poetry and sentiment has "the Lost Pleiad" been deplored!—and, to descend to more familiar illustration of this group, the "Seven Stars," the sailors' favourites, and a frequent river-side public-house sign, may be traced to the Pleiades.

CHANGE OF COLOUR IN THE STARS.

The scintillation or twinkling of the stars is accompanied by variations of colour, which have been remarked from a very early age. M. Arago states, upon the authority of M. Babinet, that the name of Barakesch, given by the Arabians to Sirius, signifies *the star of a thousand colours;* and Tycho Brahe, Kepler, and others, attest to similar change of colour in twinkling. Even soon after the invention of the telescope, Simon Marius remarked that by removing the eye-piece of the telescope the images of the stars exhibited rapid fluctuations of brightness and colour. In 1814 Nicholson applied to the telescope a smart vibration, which caused the image of the star to be transformed into a curved line of light returning into itself, and diversified by several colours; each colour occupied about a third of the whole length of the curve, and by applying ten vibrations in a second, the light of Sirius in that time passed through thirty changes of colour. Hence the stars in general shine only by a portion of their light, the effect of twinkling being to diminish their brightness. This phenomenon M. Arago explains by the principle of the interference of light.

Ptolemy is said to have noted Sirius as a *red* star, though it is now white. Sirius twinkles with red and blue light, and Ptolemy's eyes, like those of several other persons, may have been more sensitive to the *red* than to the *blue* rays.—*Sir David Brewster's More Worlds than One*, p. 235.

Some of the double stars are of very different and dissimilar colours; and to the revolving planetary bodies which apparently circulate around them, a day lightened by a red light is succeeded by, not a night, but a day equally brilliant, though illuminated only by a green light.

DISTANCE OF THE NEAREST FIXED STAR FROM THE EARTH.

Sir John Herschel wrote in 1833: "What is the distance of the nearest fixed star? What is the scale on which our visible firmament is constructed? And what proportion do its dimensions bear to those of our own immediate system? To this, however, astronomy has hitherto proved unable to supply an answer. All we know on this subject is negative." To these questions, however, an answer can now be given. Slight changes of position of some of the stars, called parallax, have been distinctly observed and measured; and among these stars No. 61 Cygni of Flamstead's catalogue has a parallax of 5″, and that of α Centauri has a proper motion of 4″ per annum.

The same astronomer states that each second of parallax indicates a distance of 20 billions of miles, or 3¼ years' journey of light. Now the light sent to us by the sun, as compared with that sent by Sirius and α Centauri, is about 22 thousand millions to 1. "Hence, from the parallax assigned above to that star, it is easy to conclude that its intrinsic splendour, as compared with that of our sun at equal distances, is 2·3247, that of the sun being unity. The light of Sirius is four times that of *a* Centauri, and its parallax only 0·15″. This, in effect, ascribes to it an intrinsic splendour equal to 96·63 times that of *a* Centauri, and therefore 224·7 times that of our sun."

This is justly regarded as one of the most brilliant triumphs of astronomical science, for the delicacy of the investigation is almost inconceivable; yet the reasoning is as unimpeachable as the demonstration of a theorem of Euclid.

LIGHT OF A STAR SIXTEENFOLD THAT OF THE SUN.

The bright star in the constellation of the Lyre, termed Vega, is the brightest in the northern hemisphere; and the combined researches of Struve, father and son, have found that the distance of this star from the earth is no less than 130 billions of miles! Light travelling at the rate of 192 thousand miles in a second consequently occupies twenty-one years in passing from this star to the earth. Now it has been found, by comparing the light of Vega with the light of the sun, that if the latter were removed to the distance of 130 billions of miles, his apparent brightness would not amount to more than the sixteenth part of the apparent brightness of Vega. We are therefore warranted in concluding that the light of Vega is equal to that of sixteen suns.

DIVERSITIES OF THE PLANETS.

In illustration of the great diversity of the physical peculiarities and probable condition of the planets, Sir John Herschel describes the intensity of solar radiation as nearly seven times greater on Mercury than on the earth, and on Uranus 330 times less; the proportion between the two extremes being that of upwards of 2000 to 1. Let any one figure to himself, (adds Sir John,) the condition of our globe were the sun to be septupled, to say nothing of the greater ratio; or were it diminished to a seventh, or to a 300th of its actual power! Again, the intensity of gravity, or its efficacy in counteracting muscular power and repressing animal activity, on Jupiter is nearly two-and-a-half times that on the earth; on Mars not more than one-half; on the moon one-sixth; and on the smaller planets probably not more than one-twentieth; giving a scale of which the extremes are in the proportion of sixty to one. Lastly, the density of Saturn hardly exceeds one-eighth of the mean density of the earth, so that it must consist of materials not much heavier than cork.

Jupiter is eleven times, Saturn ten times, Uranus five times, and Neptune nearly six times, the diameter of our earth.

These four bodies revolve in space at such distances from the sun, that if it were possible to start thence for each in succession, and to travel at the railway speed of 33 miles per hour, the traveller would reach

Jupiter in	1712 years
Saturn	3113 ,,
Uranus	6226 ,,
Neptune	9685 ,,

If, therefore, a person had commenced his journey at the period of the Christian era, he would now have to travel nearly 1300 years before he would arrive at the planet Saturn; more than 4300 years before he would reach Uranus; and no less than 7800 years before he could reach the orbit of Neptune.

Yet the light which comes to us from these remote confines of the solar system first issued from the sun, and is then reflected from the surface of the planet. When the telescope is turned towards Neptune, the observer's eye sees the object by means of light that issued from the sun eight hours before, and which since then has passed nearly twice through that vast space which railway speed would require almost a century of centuries to accomplish.—*Bouvier's Familiar Astronomy.*

GRAND RESULTS OF THE DISCOVERY OF JUPITER'S SATELLITES.

This discovery, one of the first fruits of the invention of the telescope, and of Galileo's early and happy idea of directing its newly-found powers to the examination of the heavens, forms one of the most memorable epochs in the history of astronomy. The first astronomical solution of the great problem of *the longitude*, practically the most important for the interests of mankind which has ever been brought under the dominion of strict scientific principles, dates immediately from this discovery. The final and conclusive establishment of the Copernican system of astronomy may also be considered as referable to the discovery and study of this exquisite miniature system, in which the laws of the planetary motions, as ascertained by Kepler, and specially that which connects their periods and distances, were specially traced, and found to be satisfactorily maintained. And (as if to accumulate historical interest on this point) it is to the observation of the eclipses of Jupiter's satellites that we owe the grand discovery of the aberration of light, and the consequent determination of the enormous velocity of that wonderful element—192,000 miles per second. Mr. Dawes, in 1849, first noticed the existence of round, well-defined, bright spots on the belts of Jupiter. They vary in situation and number, as many as ten having been seen on one occasion. As the belts of Jupiter have been ascribed to the existence of currents analogous to our trade-winds, causing the body of Jupiter to be visible through his cloudy atmosphere, Sir John Herschel conjectures that those bright spots may possibly be insulated masses of clouds of local origin, similar to the cumuli which sometimes cap ascending columns of vapour in our atmosphere.

It would require nearly 1300 globes of the size of our earth to make one of the bulk of Jupiter. A railway-engine travelling at the rate of thirty-three miles an hour would travel round the earth in a month, but would require more than eleven months to perform a journey round Jupiter.

WAS SATURN'S RING KNOWN TO THE ANCIENTS?

In Maurice's *Indian Antiquities* is an engraving of Sani, the Saturn of the Hindoos, taken from an image in a very ancient pagoda, which represents the deity encompassed by a *ring* formed of two serpents. Hence it is inferred that the ancients were acquainted with the existence of the ring of Saturn.

Arago mentions the remarkable fact of the ring and fourth satellite of Saturn having been seen by Sir W. Herschel with his smaller telescope by the naked eye, without any eye-piece.

The first or innermost of Saturn's satellites is nearer to the central body than any other of the secondary planets. Its distance from the centre of Saturn is 80,088 miles; from the surface of the planet 47,480 miles; and from the outmost edge of the ring only 4916 miles. The traveller may form to himself an estimate of the smallness of this amount by remembering the statement of the well-known navigator, Captain Beechey, that he had in three years passed over 72,800 miles.

According to very recent observations, Saturn's ring is divided into *three* separate rings, which, from the calculations of Mr. Bond, an American astronomer, must be fluid. He is of opinion that the number of rings is continually changing, and that their maximum number, in the normal condition of the mass, does not exceed *twenty*. Mr. Bond likewise maintains that the power which sustains the centre of gravity of the *ring* is not in the planet itself, but in its satellites; and the satellites, though constantly disturbing the ring, actually sustain it in the very act of perturbation. M. Otto Struve and Mr. Bond have lately studied with the great Munich telescope, at the observatory of Pulkowa, the *third* ring of Saturn, which Mr. Lassell and Mr. Bond discovered to be *fluid*. They saw distinctly the dark interval between this fluid ring and the two old ones, and even measured its dimensions; and they perceived at its inner margin an edge feebly illuminated, which they thought might bo the commencement of a fourth ring. These astronomers are of opinion, that the fluid ring is not of very recent formation, and that it is not subject to rapid change; and they have come to the extraordinary conclusion, that the inner border of the ring has, since the time of Huygens, been gradually approaching to the body of Saturn, and that *we may expect, sooner or later, perhaps in some dozen of years, to see the rings united with the body of the planet.* But this theory is by other observers pronounced untenable.

TEMPERATURE OF THE PLANET MERCURY.

Mercury being so much nearer to the Sun than the Earth, he receives, it is supposed, seven times more heat than the earth. Mrs. Somerville says: "On Mercury, the mean heat arising from the intensity of the sun's rays must be above that of boiling quicksilver, and water would boil even at the poles." But he may be provided with an atmosphere so constituted as to absorb or reflect a great portion of the superabundant heat; so that his inhabitants (if he have any) may enjoy a climate as temperate as any on our globe.

SPECULATIONS ON VESTA AND PALLAS.

The most remarkable peculiarities of these ultra-zodiacal planets, according to Sir John Herschel, must lie in this condition of their state: a man placed on one of them would spring with ease sixty feet high, and sustain no greater shock in his descent than he does on the earth from leaping a yard. On such planets, giants might exist; and those enormous animals which on the earth require the buoyant power of water to counteract their weight, might there be denizens of the land. But of such speculations there is no end.

IS THE PLANET MARS INHABITED?

The opponents of the doctrine of the Plurality of Worlds allow that a greater probability exists of Mars being inhabited than in the case of any other planet. His diameter is 4100 miles; and his surface exhibits spots of different hues,—the *seas*, according to Sir John Herschel, being *green*, and the land *red*. "The variety in the spots," says this astronomer, "may arise from the planet not being destitute of atmosphere and cloud; and what adds greatly to the probability of this, is the appearance of brilliant white spots at its poles, which have been conjectured, with some probability, to be snow, as they disappear when they have been long exposed to the sun, and are greatest when emerging from the long night of their polar winter, the snow-line then extending to about six degrees from the pole." "The length of the day," says Sir David Brewster, "is almost exactly twenty-four hours,—the same as that of the earth. Continents and oceans and green savannahs have been observed upon Mars, and the snow of his polar regions has been seen to disappear with the heat of summer." We actually see the clouds floating in the atmosphere of Mars, and there is the appearance of land and water on his disc. In a sketch of this planet, as seen in the pure atmosphere of Calcutta by Mr. Grant, it appears, to use his words, "actually as a little world," and as the earth would appear at a distance, with its seas and continents of different shades. As the diameter of Mars is only about one half that of our earth, the weight of bodies will be about one half what it would be if they were placed upon our globe.

DISCOVERY OF THE PLANET NEPTUNE.

This noble discovery marked in a signal manner the maturity of astronomical science. The proof, or at least the urgent presumption, of the existence of such a planet, as a means of accounting (by its attraction) for certain small irregularities observed in the motions of Uranus, was afforded almost simultaneously by the independent researches of two geometers, Mr. Adams of Cambridge, and M. Leverrier of Paris, who were enabled *from theory alone* to calculate whereabouts it ought to appear in the heavens, *if visible*, the places thus independently calculated agreeing surprisingly. *Within a single degree* of the place assigned by M. Leverrier's calculations, and by him communicated to Dr. Galle of the Royal Observatory at Berlin, it was actually found by that astronomer on the very first night after the receipt of that communication, on turning a telescope on the spot, and comparing the stars in its immediate neighbourhood with those previously laid down in one of the zodiacal charts. This remarkable verification of an indication so extraordinary took place on the 23d of September 1846.* —*Sir John Herschel's Outlines.*

Neptune revolves round the sun in about 172 years, at a mean distance of thirty,—that of Uranus being nineteen, and that of the earth one: and by its discovery the solar system has been extended *one thousand millions of miles* beyond its former limit.

Neptune is suspected to have a ring, but the suspicion has not been confirmed. It has been demonstrated by the observations of Mr. Lassell, M. Otto Struve, and Mr. Bond, to be attended by at least one satellite.

One of the most curious facts brought to light by the discovery of Neptune, is the failure of Bode's law to give an approximation to its distance from the sun; a striking exemplification of the danger of trusting to the universal applicability of an empirical law. After standing the severe test which led

* Professor Challis, of the Cambridge Observatory, directing the Northumberland telescope of that institution to the place assigned by Mr. Adams's calculations and its vicinity on the 4th and 12th of August 1846, saw the planet on both those days, and noted its place (among those of other stars) for re-observation. He, however, postponed the *comparison* of the places observed, and not possessing Dr. Bremiker's chart (which would at once have indicated the presence of an unmapped star), remained in ignorance of the planet's existence as a visible object till the announcement of such by Dr. Galle.

to the discovery of the asteroids, it seemed almost contrary to the laws of probability that the discovery of another member of the planetary system should prove its failure as an universal rule.

MAGNITUDE OF COMETS.

Although Comets have a smaller mass than any other cosmical bodies—being, according to our present knowledge, probably not equal to $\frac{1}{5000}$th part of the earth's mass—yet they occupy the largest space, as their tails in several instances extend over many millions of miles. The cone of luminous vapour which radiates from them has been found in some cases (as in 1680 and 1811) equal to the length of the earth's distance from the sun, forming a line that intersects both the orbits of Venus and Mercury. It is even probable that the vapour of the tails of comets mingled with our atmosphere in the years 1819 and 1823.—*Humboldt's Cosmos*, vol. i.

COMETS VISIBLE IN SUNSHINE—THE GREAT COMET OF 1843.

The phenomenon of the tail of a Comet being visible in bright Sunshine, which is recorded of the comet of 1402, occurred again in the case of the large comet of 1843, whose nucleus and tail were seen in North America on February 28th (according to the testimony of J. G. Clarke, of Portland, State of Maine), between one and three o'clock in the afternoon. The distance of the very dense nucleus from the sun's light admitted of being measured with much exactness. The nucleus and tail (a darker space intervening) appeared like a very pure white cloud.—*American Journal of Science*, vol. xiv.

E. C. Otté, the translator of Bohn's edition of Humboldt's *Cosmos*, at New Bedford, Massachusetts, U.S., Feb. 28th, 1843, distinctly saw the above comet between one and two in the afternoon. The sky at the time was intensely blue, and the sun shining with a dazzling brightness unknown in European climates.

This very remarkable Comet, seen in England on the 17th of March 1843, had a nucleus with the appearance of a planetary disc, and the brightness of a star of the first or second magnitude. It had a double tail divided by a dark line. At the Cape of Good Hope it was seen in full daylight, and in the immediate vicinity of the sea; but the most remarkable fact in its history was its near approach to the sun, its distance from his surface being only *one-fourteenth* of his diameter. The heat to which it was exposed, therefore, was much greater than that which Sir Isaac Newton ascribed to the comet of 1680, namely 200 times that of red-hot iron. Sir John Herschel has computed that it must have been 24 times greater than that which was produced in the focus of Parker's burning lens, 32 inches in diameter, which melts crystals of quartz and agate.*

THE MILKY WAY UNFATHOMABLE.

M. Struve of Pulkowa has compared Sir William Herschel's opinion on this subject, as maintained in 1785, with that to which he was subsequently led; and arrives at the conclusion that, according to Sir W. Herschel himself, the visible extent of the Milky Way increases with the penetrating power of the telescopes employed; that it is impossible to discover by his instruments the termination of the Milky Way (as an independent cluster of stars); and that even his gigantic telescope of forty feet focal length does not enable him to extend our knowledge of the Milky Way, which is incapable of being sounded. Sir William Herschel's *Theory of the Milky Way* was as follows: He considered our solar system, and all the stars which we can see with the eye, as placed within, and constituting a part of, the nebula of the Milky Way, a congeries of many millions of stars, so that the projection of these stars must form a luminous track on the concavity of the sky; and by estimating or counting the number of stars in different directions, he was able to form a rude judgment of the probable form of the nebula, and of the probable position of the solar system within it.

This remarkable belt has maintained from the earliest ages the same relative situation among the stars; and, when examined through powerful telescopes, is found (wonderful to relate!) *to consist entirely of stars scattered by millions*, like glittering dust, on the black ground of the general heavens.

DISTANCES OF NEBULÆ.

These are truly astounding. Sir William Herschel estimated the distance of the annular nebula between Beta and Gamma Lyræ to be from our system 950 times that of Sirius; and a globular cluster about 5½° south-east of Beta Sir William computed to be one thousand three hundred billions of miles from our system. Again, in Scutum Sobieski is one nebula in the shape of a horseshoe; but which, when viewed with high magnifying power, presents a different appearance. Sir William Herschel estimated this nebula to be 900 times farther from us than Sirius. In some parts of its vicinity he observed 588 stars in his telescope at one time; and he counted 258,000 in a space 10° long and 2½° wide. There is a globular cluster between the mouths of Pegasus and Equuleus, which Sir William Herschel estimated to be 243 times farther from us than Sirius. Caroline Herschel discovered in the right foot of Andromeda a nebula of enormous dimensions, placed at an inconceivable distance from us: it consists probably of myriads of solar systems, which, taken together, are but a point in the universe. The nebula about 10° west of the principal star in Triangulum is supposed by Sir William Herschel to be 344 times the distance of Sirius from the earth, which would be the immense sum of nearly seventeen thousand billions of miles from our planet.

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* For several interesting details of Comets, see "Destruction of the World by a Comet," in *Popular Errors Explained and Illustrated*, new edit. pp. 165-168.

INFINITE SPACE.

After the straining mind has exhausted all its resources in attempting to fathom the distance of the smallest telescopic star, or the faintest nebula, it has reached only the visible confines of the sidereal creation. The universe of stars is but an atom in the universe of space; above it, and beneath it, and around it, there is still infinity.

ORIGIN OF OUR PLANETARY SYSTEM. THE NEBULAR HYPOTHESIS.[*]

The commencement of our Planetary System, including the sun, must, according to Kant and Laplace, be regarded as an immense nebulous mass filling the portion of space which is now occupied by our system far beyond the limits of Neptune, our most distant planet. Even now we perhaps see similar masses in the distant regions of the firmament, as patches of nebulæ, and nebulous stars; within our system also, comets, the zodiacal light, the corona of the sun during a total eclipse, exhibit resemblances of a nebulous substance, which is so thin that the light of the stars passes through it unenfeebled and unrefracted. If we calculate the density of the mass of our planetary system, according to the above assumption, for the time when it was a nebulous sphere which reached to the path of the outmost planet, we should find that it would require several cubic miles of such matter to weigh a single grain.—*Professor Helmholtz.*

A quarter of a century ago, Sir John Herschel expressed his opinion that those nebulæ which were not resolved into individual stars by the highest powers then used, might be hereafter completely resolved by a further increase of optical power:

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[*] The letters of Sir Isaac Newton to Dr. Bentley, containing suggestions for the Boyle Lectures, possess a peculiar interest in the present day. "They show" (says Sir David Brewster) "that the *nebular hypothesis*, the dull and dangerous heresy of the age, is incompatible with the established laws of the material universe, and that an omnipotent arm was required to give the planets their positions and motions in space, and a presiding intelligence to assign to them the different functions they had to perform."—*Life of Newton*, vol. ii.

In fact, this probability has almost been converted into a certainty by the magnificent reflecting telescope constructed by Lord Rosse, of 6 feet in aperture, which has resolved, or rendered resolvable, multitudes of nebulæ which had resisted all inferior powers. The sublimity of the spectacle afforded by that instrument of some of the larger globular and other clusters is declared by all who have witnessed it to be such as no words can express.*

Although, therefore, nebulæ do exist, which even in this powerful telescope appear as nebulæ, without any sign of resolution, it may very reasonably be doubted whether there be really any essential physical distinction between nebulæ and clusters of stars, at least in the nature of the matter of which they consist; and whether the distinction between such nebulæ as are easily resolved, barely resolvable with excellent telescopes, and altogether irresolvable with the best, be any thing else than one of degree, arising merely from the excessive minuteness and multitude of the stars of which the latter, as compared with the former, consist.—*Outlines of Astronomy,* 5th edit. 1858.

It should be added, that Sir John Herschel considers the "nebular hypothesis" and the above theory of sidereal aggregation to stand quite independent of each other.

ORIGIN OF HEAT IN OUR SYSTEM.

Professor Helmholtz, assuming that at the commencement the density of the nebulous matter was a vanishing quantity, as compared with the present density of the sun and planets, calculates how much work has been performed by the condensation; how much of this work still exists in the form of mechanical force, as attraction of the planets towards the sun, and as *vis viva* of their motion; and finds by this how much of the force has been converted into heat.

The result of this calculation is, that only about the 45th part of the original mechanical force remains as such, and that the remainder, converted into heat, would be sufficient to raise a mass of water equal to the sun and planets taken together, not less than 28,000,000 of degrees of the centigrade scale. For the sake of comparison, Professor Helmholtz mentions that the highest temperature which we can produce by the oxy-hydrogen blowpipe, which is sufficient to vaporise even platina, and which but few bodies can endure, is estimated at about 2000 degrees. Of the action of a temperature of 28,000.000 of such degrees we can form no notion. If the mass of our entire system were of pure coal, by the combustion of the whole of it only the 350th part of the above quantity would be generated.

The store of force at present possessed by our system is equivalent to immense quantities of heat. If our earth were by a sudden shock brought to rest in her orbit—which is not to be feared in the existing arrangement of our system—by such a shock a quantity of heat would be generated equal to that produced by the combustion of fourteen such earths of solid coal. Making the most unfavourable assumption as to its capacity for heat, that is, placing it equal to that of water, the mass of the earth would thereby be heated 11,200°; it would therefore be quite fused, and for the most part reduced to vapour. If, then, the earth, after having been thus brought to rest, should fall into the sun, which of course would be the case, the quantity of heat developed by the shock would be 400 times greater.

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* The constitution of the nebulæ in the constellation of Orion has been resolved by this instrument; and by its aid the stars of which it is composed burst upon the sight of man for the first time.

AN ASTRONOMER'S DREAM VERIFIED.

The most fertile region in astronomical discovery during the last quarter of a century has been the planetary members of the solar system. In 1833, Sir John Herschel enumerated ten planets as visible from the earth, either by the unaided eye or by the telescope; the number is now increased more than five-fold. With the exception of Neptune, the discovery of new planets is confined to the class called Asteroids. These all revolve in elliptic orbits between those of Jupiter and Mars. Zitius of Wittemberg discovered an empirical law, which seemed to govern the distances of the planets from the sun; but there was a remarkable interruption in the law, according to which a planet ought to have been placed between Mars and Jupiter. Professor Bode of Berlin directed the attention of astronomers to the possibility of such a planet existing; and in seven years' observations from the commencement of the present century, not one but four planets were found, differing widely from one another in the elements of their orbits, but agreeing very nearly at their mean distances from the sun with that of the supposed planet. This curious coincidence of the mean distances of these four asteroids with the planet according to Bode's law, as it is generally called, led to the conjecture that these four planets were but fragments of the missing planet, blown to atoms by some internal explosion, and that many more fragments might exist, and be possibly discovered by diligent search.

Concerning this apparently wild hypothesis, Sir John Herschel offered the following remarkable apology: "This may serve as a specimen of the dreams in which astronomers, like other speculators, occasionally and harmlessly indulge."

The dream, wild as it appeared, has been realised now. Sir John, in the fifth edition of his *Outlines of Astronomy*, published in 1858, tells us:

> Whatever may be thought of such a speculation as a physical hypothesis, this conclusion has been verified to a considerable extent as a matter of fact by subsequent discovery, the result of a careful and minute examination and mapping down of the smaller stars in and near the zodiac, undertaken with that express object. Zodiacal charts of this kind, the product of the zeal and industry of many astronomers, have been constructed, in which every star down to the ninth, tenth, or even lower magnitudes, is inserted; and these stars being compared with the actual stars of the heavens, the intrusion of any stranger within their limits cannot fail to be noticed when the comparison is systematically

conducted. The discovery of Astræa and Hebe by Professor Hencke, in 1845 and 1847, revived the flagging spirit of inquiry in this direction; with what success, the list of fifty-two asteroids, with their names and the dates of their discovery, will best show. The labours of our indefatigable countryman, Mr. Hind, have been rewarded by the discovery of no less than eight of them.

FIRE-BALLS AND SHOOTING STARS.

Humboldt relates, that a friend at Popayan, at an elevation of 5583 feet above the sea-level, at noon, when the sun was shining brightly in a cloudless sky, saw his room lighted up by a fire-ball: he had his back towards the window at the time, and on turning round, perceived that great part of the path traversed by the fire-ball was still illuminated by the brightest radiance. The Germans call these phenomena *star-snuff*, from the vulgar notion that the lights in the firmament undergo a process of snuffing, or cleaning. Other nations call it *a shot or fall of stars*, and the English *star-shoot*. Certain tribes of the Orinoco term the pearly drops of dew which cover the beautiful leaves of the heliconia *star-spit*. In the Lithuanian mythology, the nature and signification of falling stars are embodied under nobler and more graceful symbols. The Parcæ, *Werpeja*, weave in heaven for the new-born child its thread of fate, attaching each separate thread to a star. When death approaches the person, the thread is rent, and the star wanes and sinks to the earth.—*Jacob Grimm.*

THEORY AND EXPERIENCE.

In the perpetual vicissitude of theoretical views, says the author of *Giordano Bruno*, "most men see nothing in philosophy but a succession of passing meteors; whilst even the grander forms in which she has revealed herself share the fate of comets,—bodies that do not rank in popular opinion amongst the external and permanent works of nature, but are regarded as mere fugitive apparitions of igneous vapour."

METEORITES FROM THE MOON.

The hypothesis of the selenic origin of meteoric stones depends upon a number of conditions, the accidental coincidence f which could alone convert a possible to an actual fact. The iew of the original existence of small planetary masses in space s simpler, and at the same time more analogous with those ntertained concerning the formation of other portions of the olar system.

Diogenes Laertius thought aerolites came from the sun; but Pliny erides this theory. The fall of aerolites in bright sunshine, and when he moon's disc was invisible, probably led to the idea of sun-stones. oreover Anaxagoras regarded the [illegible] as "a molten fiery mass;" and

Euripides, in Phaëton, terms the sun "a golden mass," that is to say, a fire-coloured, brightly-shining matter, but not leading to the inference that aerolites are golden sun-stones. The Greek philosophers had four hypotheses as to their origin: telluric, from ascending exhalations; masses of stone raised by hurricanes; a solar origin; and lastly, an origin in the regions of space, as heavenly bodies which had long remained invisible: the last opinion entirely according with that of the present day.

Chladni states that an Italian physicist, Paolo Maria Terzago, on the occasion of the fall of an aerolite at Milan, in 1660, by which a Franciscan monk was killed, was the first who surmised that aerolites were of selenic origin. Without any previous knowledge of this conjecture, Olbers was led, in 1795 (after the celebrated fall at Siena, June 16th, 1794), to investigate the amount of the initial tangential force that would be required to bring to the earth masses projected from the moon. Olbers, Brandes, and Chaldni thought that "the velocity of 16 to 32 miles, with which fire-balls and shooting-stars entered our atmosphere," furnished a refutation to the view of their selenic origin. According to Olbers, it would require to reach the earth, setting aside the resistance of the air, an initial velocity of 8292 feet in the second; according to Laplace, 7862; to Biot, 8282; and to Poisson, 7595. Laplace states that this velocity is only five or six times as great as that of a cannon-ball; but Olbers has shown that "with such an initial velocity as 7500 or 8000 feet in a second, meteoric stones would arrive at the surface of our earth with a velocity of only 35,000 feet." But the measured velocity of meteoric stones averages upwards of 114,000 feet to a second; consequently the original velocity of projection from the moon must be almost 110,000 feet, and therefore 14 times greater than Laplace asserted. It must, however, be recollected, that the opinion then so prevalent, of the existence of active volcanoes in the moon, where air and water are absent, has since been abandoned.

Laplace elsewhere states, that in all probability aerolites "come from the depths of space;" yet he in another passage inclines to the hypothesis of their lunar origin, always, however, assuming that the stones projected from the moon "become satellites of our earth, describing around it more or less eccentric orbits, and thus not reaching its atmosphere until several or even many revolutions have been accomplished."

In Syria there is a popular belief that aerolites chiefly fall on clear moonlight nights. The ancients (Pliny tells us) looked for their fall during lunar eclipses.—*Abridged from Humboldt's Cosmos,* vol. i. (Bohn's edition).

Dr. Laurence Smith, U.S., accepts the "lunar theory," and considers meteorites to be masses thrown off from the moon, the attractive power of which is but one-sixth that of the earth; so that bodies thrown from the surface of the moon experience but one sixth the retarding force they would have when thrown from the earth's surface.

Look again (says Dr. Smith) at the constitution of the meteorite, made up principally of *pure* iron. It came evidently from some place where there is little or no oxygen. Now the moon has no atmosphere, and no water on its surface. There is no oxygen there. Hurled from the moon, these bodies,—these masses of almost pure iron,—would flame in the sun like polished steel, and on reaching our atmosphere would burn in its oxygen until a black oxide cooled it; and this we find to be the case with all meteorites,—the black colour is only an external covering.

Sir Humphry Davy, from facts contained in his researches on flame, in 1817, conceives that the light of meteors depends, not upon the ignition of inflammable gases, but upon that of solid bodies; that such is their velocity of motion, as to excite sufficient heat for their ignition by the compression even of rare air; and that the phenomena of falling stars may be explained by regarding them as small incombustible bodies moving round the earth in very eccentric orbits, and becoming ignited only when they pass with immense rapidity through the upper regions of the atmosphere; whilst those meteors which throw down stony bodies are, similarly circumstanced, combustible masses.

Masses of iron and nickel, having all the appearance of aerolites or meteoric stones, have been discovered in Siberia, at a depth of ten metres below the surface of the earth. From the fact, however, that no meteoric stones are found in the secondary and tertiary formations, it would seem to follow that the phenomena of falling stones did not take place till the earth assumed its present conditions.

VAST SHOWER OF METEORS.

The most magnificent Shower of Meteors that has ever been known was that which fell during the night of November 12th, 833, commencing at nine o'clock in the evening, and continuing till the morning sun concealed the meteors from view. This hower extended from Canada to the northern boundary of South America, and over a tract of nearly 3000 miles in width.

IMMENSE METEORITE.

Mrs. Somerville mentions a Meteorite which passed within wenty-five miles of our planet, and was estimated to weigh 100,000 tons, and to move with a velocity of twenty miles in a econd. Only a small fragment of this immense mass reached he earth. Four instances are recorded of persons being killed y their fall. A block of stone fell at Ægos Potamos, B.C. 465, s large as two millstones; another at Narni, in 921, projected ke a rock four feet above the surface of the river, in which it as seen to fall. The Emperor Jehangire had a sword forged om a mass of meteoric iron, which fell in 1620 at Jahlinder n the Punjab. Sixteen instances of the fall of stones in the ritish Isles are well authenticated to have occurred since 1620, ne of them in London. It is very remarkable that no new hemical element has been detected in any of the numerous eteorites which have been analysed.

NO FOSSIL METEORIC STONES.

It is (says Olbers) a remarkable but hitherto unregarded fact, that while shells are found in secondary and tertiary formations, no Fossil Meteoric Stones have as yet been discovered. May we conclude from this circumstance, that previous to the present and last modification of the earth's surface no meteoric stones fell on it, though at the present time it appears probable, from the researches of Schreibers, that 700 fall annually?*

THE END OF OUR SYSTEM.

While all the phenomena in the heavens indicate a law of progressive creation, in which revolving matter is distributed into suns and planets, there are indications in our own system that a period has been assigned for its duration, which, sooner or later, it must reach. The medium which fills universal space, whether it be a luminiferous ether, or arise from the indefinite expansion of planetary atmospheres, must retard the bodies which move in it, even were it 360,000 millions of times more rare than atmospheric air; and, with its time of revolution gradually shortening, the satellite must return to its planet, the planet to its sun, and the sun to its primeval nebula. The fate of our system, thus deduced from mechanical laws, must be the fate of all others. Motion cannot be perpetuated in a resisting medium; and where there exist disturbing forces, there must be primarily derangement, and ultimately ruin. From the great central mass, heat may again be summoned to exhale nebulous matter; chemical forces may again produce motion, and motion may again generate systems; but, as in the recurring catastrophes which have desolated our earth, the great First Cause must preside at the dawn of each cosmical cycle; and, as in the animal races which were successively reproduced, new celestial creations of a nobler form of beauty and of a higher form of permanence may yet appear in the sidereal universe. "Behold, I create new heavens and a new earth, and the former shall not be remembered." "The new heavens and the new earth shall remain before me." "Let us look, then, according to this promise, for the new heavens and the new earth, wherein dwelleth righteousness."—*North-British Review*, No. 3.

BENEFITS OF GLASS TO MAN.

Cuvier eloquently says: "It could not be expected that those Phœnician sailors who saw the sand of the shores of Bætica transformed by fire into a transparent Glass, should have at once foreseen that this new substance would prolong the pleasures of sight to the old; that it would one day assist the astronomer in penetrating the depths of the heavens, and in numbering the stars of the Milky Way; that it would lay open to the naturalist a miniature world, as populous, as rich in wonders as that which alone seemed to have been granted to his senses and his contemplation: in fine, that the most simple and direct use of it would enable the inhabitants of the coast of the Baltic Sea to build palaces more magnificent than those of Tyre and Memphis, and to cultivate, almost under the polar circle, the most delicious fruit of the torrid zone."

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* Several specimens of Meteoric Iron are to be seen in the Mineralogical Collection in the British Museum.

THE GALILEAN TELESCOPE.

Galileo appears to be justly entitled to the honour of having invented that form of Telescope which still bears his name; while we must accord to John Lippershey, the spectacle-maker of Middleburg, the honour of having previously invented the astronomical telescope. The interest excited at Venice by Galileo's invention amounted almost to frenzy. On ascending the tower of St. Mark, that he might use one of his telescopes without molestation, Galileo was recognised by a crowd in the street, who took possession of the wondrous tube, and detained the impatient philosopher for several hours, till they had successively witnessed its effects. These instruments were soon manufactured in great numbers; but were purchased merely as philosophical toys, and were carried by travellers into every corner of Europe.

WHAT GALILEO FIRST SAW WITH HIS TELESCOPE.

The moon displayed to him her mountain-ranges and her glens, her continents and her highlands, now lying in darkness, now brilliant with sunshine, and undergoing all those variations of light and shadow which the surface of our own globe presents to the alpine traveller or to the aeronaut. The four satellites of Jupiter illuminating their planet, and suffering eclipses in his shadow, like our own moon; the spots on the sun's disc, proving his rotation round his axis in twenty-five days; the crescent phases of Venus, and the triple form or the imperfectly developed ring of Saturn,—were the other discoveries in the solar system which rewarded the diligence of Galileo. In the starry heavens, too, thousands of new worlds were discovered by his telescope; and the Pleiades alone, which to the unassisted eye exhibit only *seven* stars, displayed to Galileo no fewer than *forty*.—*North-British Review*, No. 3.

The first telescope "the starry Galileo" constructed with a leaden tube a few inches long, with a spectacle-glass, one convex and one concave, at each of its extremities. It magnified three times. Telescopes were made in London in February 1610, a year after Galileo had completed his own (Rigaud, *On Harriot's Papers*, 1833). They were at first called *cylinders*. The telescopes which Galileo constructed, and others of which he made use for observing Jupiter's satellites, the phases of Venus, and the solar spots, possessed the gradually-increasing powers of magnifying four, seven, and thirty-two linear diameters; but they never had a higher power.—Arago, in the *Annuaire* for 1842.

Clock-work is now applied to the equatorial telescope, so as to allow the observer to follow the course of any star, comet, or planet he may wish to observe continuously, without using his hands for the mechanical motion of the instrument.

ANTIQUITY OF TELESCOPES.

Long tubes were certainly employed by Arabian astronomers, and very probably also by the Greeks and Romans; the exactness of their observations being in some degree attributable to their causing the object to be seen through diopters or slits. Abul Hassan speaks very distinctly of tubes, to the extremities of which ocular and object diopters were attached; and instruments so constructed were used in the observatory founded by Hulagu at Meragha. If stars be more easily discovered during twilight by means of tubes, and if a star be sooner revealed to the naked eye through a tube than without it, the reason lies, as Arago has truly observed, in the circumstance that the tube conceals a great portion of the disturbing light diffused in the atmospheric strata between the star and the eye applied to the tube. In like manner, the tube prevents the lateral impression of the faint light which the particles of air receive at night from all the other stars in the firmament. The intensity of the image and the size of the star are apparently augmented.—*Humboldt's Cosmos*, vol. iii. p. 53.

NEWTON'S FIRST REFLECTING TELESCOPE.

The year 1668 may be regarded as the date of the invention of Newton's Reflecting Telescope. Five years previously, James Gregory had described the manner of constructing a reflecting telescope with two concave specula; but Newton perceived the disadvantages to be so great, that, according to his statement, he "found it necessary, before attempting any thing in the practice, to alter the design, and place the eye-glass at the side of the tube rather than at the middle." On this improved principle Newton constructed his telescope, which was examined by Charles II.; it was presented to the Royal Society near the end of 1671, and is carefully preserved by that distinguished body, with the inscription:

"THE FIRST REFLECTING TELESCOPE; INVENTED BY SIR ISAAC NEWTON,
AND MADE WITH HIS OWN HANDS."

Sir David Brewster describes this telescope as consisting of a concave metallic speculum, the radius of curvature of which was 12⅔ or 13 inches, so that "it collected the sun's rays at the distance of 6⅓ inches." The rays reflected by the speculum were received upon a plane metallic speculum inclined 45° to the axis of the tube, so as to reflect them to the side of the tube in which there was an aperture to receive a small tube with a plano-convex eye-glass whose radius was one-twelfth of an inch, by means of which the image formed by the speculum was magnified 38 times. Such was the first reflecting telescope applied to the heavens; but Sir David Brewster describes this instrument as small and ill-made; and fifty years elapsed before telescopes of the Newtonian form became useful in astronomy.

SIR WILLIAM HERSCHEL'S GREAT TELESCOPE AT SLOUGH.

The plan of this Telescope was intimated by Herschel, through Sir Joseph Banks, to George III., who offered to defray the whole expense of it; a noble act of liberality, which has never been imitated by any other British sovereign. Towards the close of 1785, accordingly, Herschel began to construct his reflecting telescope, *forty feet in length*, and having a speculum *fully four feet in diameter.* The thickness of the speculum, which was uniform in every part, was 3½ inches, and its weight nearly 2118 pounds; the metal being composed of 32 copper, and 10·7 of tin: it was the third speculum cast, the two previous attempts having failed. The speculum, when not in use, was preserved from damp by a tin cover, fitted upon a rim of close-grained cloth. The tube of the telescope was 39 ft. 4 in. long, and its width 4 ft. 10 in.; it was made of iron, and was 3000 lbs. lighter than if it had been made of wood. The observer was seated in a suspended movable seat at the mouth of the tube, and viewed the image of the object with a magnifying lens or eye-piece. The focus of the speculum, or place of the image, was within four inches of the lower side of the mouth of the tube, and came forward into the air, so that there was space for part of the head above the eye, to prevent it from intercepting many of the rays going from the object to the mirror. The eye-piece moved in a tube carried by a slider directed to the centre of the speculum, and fixed on an adjustible foundation at the mouth of the tube. It was completed on the 27th August 1789; and *the very first moment* it was directed to the heavens, a new body was added to the solar system, namely, Saturn and six of its satellites; and in less than a month after, the seventh satellite of Saturn, "an object," says Sir John Herschel, "of a far higher order of difficulty."—*Abridged from the North-British Review*, No. 3.

This magnificent instrument stood on the lawn in the rear of Sir William Herschel's house at Slough; and some of our readers, like ourselves, may remember its extraordinary aspect when seen from the Bath coach-road, and the road to Windsor. The difficulty of managing so large an instrument—requiring as it did two assistants in addition to the observer himself and the person employed to note the time—prevented its being much used. Sir John Herschel, in a letter to Mr. Weld, states the entire cost of its construction, 4000*l.*, was defrayed by George III. In 1839, the woodwork of the telescope being decayed, Sir John Herschel had it cleared away; and piers were erected, on which the tube was placed, *that* being of iron, and so well preserved that, although not more than one-twentieth of an inch thick, when in the horizontal position it contained within all Sir John's family; and next the two reflectors, the polishing apparatus, and portions of the machinery, to the amount of a great many tons. Sir John attributes this great strength and resistance to the internal structure of the tube, very similar to that patented under the name of corrugated iron-roping. Sir John Herschel also thinks that system of triangular arrangement of the woodwork was upon the priuciple to which "diagonal bracing" owes its strength.

THE EARL OF ROSSE'S GREAT REFLECTING TELESCOPE.

Sir David Brewster has remarked, that "the long interval of half a century seems to be the period of hybernation during which the telescopic mind rests from its labours in order to acquire strength for some great achievement. Fifty years elapsed between the dwarf telescope of Newton and the large instruments of Hadley; other fifty years rolled on before Sir William Herschel constructed his magnificent telescope; and fifty years more passed away before the Earl of Rosse produced that colossal instrument which has already achieved such brilliant discoveries."*

In the improvement of the Reflecting Telescope, the first object has always been to increase the magnifying power and light by the construction of as large a mirror as possible; and to this point Lord Rosse's attention was directed as early as 1828, the field of operation being at his lordship's seat, Birr Castle at Parsonstown, about fifty miles west of Dublin. For this high branch of scientific inquiry Lord Rosse was well fitted by a rare combination of "talent to devise, patience to bear disappointment, perseverance, profound mathematical knowledge, mechanical skill, and uninterrupted leisure from other pursuits;"† all these, however, would not have been sufficient, had not a great command of money been added; the gigantic telescope we are about to describe having cost certainly not less than twelve thousand pounds.

Lord Rosse ground and polished specula fifteen inches, two feet, and three feet in diameter before he commenced the colossal instrument. It is impossible here to detail the admirable contrivances and processes by which he prepared himself for this great work. He first ascertained the most useful combination of metals for specula, both in whiteness, porosity, and hardness, to be copper and tin. Of this compound the reflector was cast in pieces, which were fixed on a bed of zinc and copper, —a species of brass which expanded in the same degree by heat as the pieces of the speculum themselves. They were ground as one body to a true surface, and then polished by machinery moved by a steam-engine. The peculiarities of this mechanism were entirely Lord Rosse's invention, and the result of close calculation and observation: they were chiefly, placing the speculum with the face upward, regulating the temperature by having it immersed in water, usually at 55° Fahr., and regulating the pressure and velocity. This was found to work a perfect spherical figure in large surfaces with a degree of precision unattainable by the hand; the polisher, by working above and upon the face of the speculum, being enabled to examine the operation as it proceeded without removing the speculum, which, when a ton weight, is no easy matter.

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* *Life of Sir Isaac Newton,* vol. i. p. 62.

† *Description of the Monster Telescope,* by Thomas Woods, M.D 4th edit. 1851.

The contrivance for doing this is very beautiful. The machine is placed in a room at the bottom of a high tower, in the successive floors of which trap-doors can be opened. A mast is elevated on the top of the tower, so that its summit is about ninety feet *above* the speculum. A dial-plate is attached to the top of the mast, and a small plane speculum and eye-piece, with proper adjustments, are so placed that the combination becomes a Newtonian telescope, and the dial-plate the object. The last and most important part of the process of working the specu-um, is to give it a *true parabolic figure*, that is, such a figure that each ortion of it should reflect the incident ray to the same focus. Lord Rosse's operations for this purpose consist—1st, of a stroke of the first ccentric, which carries the polisher along *one-third* of the diameter of he speculum; 2d, a transverse stroke twenty-one times slower, and qual to 0·27 of the same diameter, measured on the edge of the tank, r 1·7 beyond the centre of the polisher; 3d, a rotation of the speculum erformed in the same time as thirty-seven of the first strokes; and th, a rotation of the polisher in the same direction about sixteen times ower. If these rules are attended to, the machine will give the true rabolic figure to the speculum, whether it be *six inches* or *three feet* *diameter*. In the three-feet speculum, the figure is so true with the hole aperture, that it is thrown out of focus by a motion of less than e *thirtieth of an inch*, "and even with a single lens of one-eighth of inch focus, giving a power of 2592, the dots on a watch-dial are still some degree defined."

Thus was executed the three-feet speculum for the twenty-x-feet telescope placed upon the lawn at Parsonstown, which, 1840, showed with powers up to 1000 and even 1600; and ich resolved nebulæ into stars, and destroyed that symmetry form in globular nebulæ upon which was founded the hypoesis of the gradual condensation of nebulous matter into suns d planets.*

Scarcely was this instrument out of Lord Rosse's hands, en he resolved to attempt by the same processes to construct another reflector, with a speculum *six feet* in diameter and *fifty feet long!* and this magnificent instrument was completed early in 1845. The focal length of the speculum is fifty-four feet. It weighs four tons, and, with its supports, is seven times as heavy as the four-feet speculum of Sir William Herschel. The speculum is placed in one of the sides of a cubical wooden box, about eight feet wide, and to the opposite end of this box is fastened the tube, which is made of deal staves an inch thick, hooped with iron clamp-rings, like a huge cask. It carries at its upper end, and in the axis of the tube, a small oval speculum, six inches in its lesser diameter.

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* This instrument also discovered a multitude of new objects in the moon; mountainous tract near Ptolemy, every ridge of which is dotted with exnely minute craters, and two black parallel stripes in the bottom of Aristar-s. Dr. Robinson, in his address to the British Association in 1843, stated that his telescope a building the size of the Court-house at Cork would be easily ble on the lunar surface.

The tube is about 50 feet long and 8 feet in diameter in the middle, and furnished with diaphragms 6½ feet in aperture. The late Dean of Ely walked through the tube with an umbrella up.

The telescope is established between two lofty castellated piers 60 feet high, and is raised to different altitudes by a strong chain-cable attached to the top of the tube. This cable passes over a pulley on a frame down to a windlass on the ground, which is wrought by two assistants. To the frame are attached chain-guys fastened to the counterweights; and the telescope is balanced by these counterweights suspended by chains, which are fixed to the sides of the tube and pass over large iron pulleys. The immense mass of matter weighs about twelve tons.

On the eastern pier is a strong semicircle of cast-iron, with which the telescope is connected by a racked bar, with friction-rollers attached to the tubè by wheelwork, so that by means of a handle near the eye-piece, the observer can move the telescope along the bar on either side of the meridian, to the distance of an hour for an equatorial star.

On the western pier are stairs and galleries. The observing gallery is moved along a railway by means of wheels and a winch; and the mechanism for raising the galleries to various altitudes is very ingenious. Sometimes the galleries, filled with observers, are suspended midway between the two piers, over a chasm sixty feet deep.

An excellent description of this immense Telescope at Birr Castle will be found in Mr. Weld's volume of *Vacation Rambles.*

Sir David Brewster thus eloquently sketches the powers of the telescope at the close of his able description of the instrument, which we have in part quoted from his *Life of Sir Isaac Newton.*

> We have, in the mornings, walked again and again, and ever with new delight, along its mystic tube, and at midnight, with its distinguished architect, pondered over the marvellous sights which it dis-

closes,—the satellites and belts and rings of Saturn,—the old and new ring, which is advancing with its crest of waters to the body of the planet,—the rocks, and mountains, and valleys, and extinct volcanoes of the moon,—the crescent of Venus, with its mountainous outline,—the systems of double and triple stars,—the nebulæ and starry clusters of every variety of shape,—and those spiral nebular formations which baffle human comprehension, and constitute the greatest achievement in modern discovery.

The Astronomer Royal, Mr. Airy, alludes to the impression made by the enormous light of the telescope,—partly by the modifications produced in the appearance of nebulæ already figured, partly by the great number of stars seen at a distance from the Milky Way, and partly from the prodigious brilliancy of Saturn. The account given by another astronomer of the appearance of Jupiter was that it resembled a coach-lamp in the telescope; and this well expresses the blaze of light which is seen in the instrument.

The Rev. Dr. Scoresby thus records the results of his visits :

The range opened to us by the great telescope at Birr Castle is best, perhaps, apprehended by the now usual measurement—not of distances in miles, or millions of miles, or diameters of the earth's orbit, but—of the progress of light in free space. The determination within, no doubt, a small proportion of error of the parallax of a considerable number of the fixed stars yields, according to Mr. Peters, a space betwixt us and the fixed stars of the smallest magnitude, the sixth, ordinarily visible to the naked eye, of 130 years in the flight of light. This information enables us, on the principles of *sounding the heavens*, suggested by Sir W. Herschel, with the photometrical researches on the tars of Dr. Wollaston and others, to carry the estimation of distances, and that by no means on vague assumption, to the limits of space pened out by the most effective telescopes. And from the guidance hus afforded us as to the comparative power of the six-feet speculum n the penetration of space as already elucidated, we might fairly as-ume the fact, that if any other telescope now in use could follow the un if removed to the remotest visible position, or till its light would equire 10,000 years to reach us, the grand instrument at Parsonstown ould follow it so far that from 20,000 to 25,000 years would be spent in he transmission of its light to the earth. But in the cases of clusters f stars, and of nebulæ exhibiting a mere speck of misty luminosity, om the combined light of perhaps hundreds of thousands of suns, the *enetration* into space, compared with the results of ordinary vision, ust be enormous ; so that it would not be difficult to show the *proba-lity* that a million of years, in flight of light, would be requisite, in gard to the most distant, to trace the enormous interval.

GIGANTIC TELESCOPES PROPOSED.

Hooke is said to have proposed the use of Telescopes having length of upwards of 10,000 feet (or nearly two miles), in der to see animals in the moon ! an extravagant expectation hich Auzout considered it necessary to refute. The Capuchin onk Schyrle von Rheita, who was well versed in optics, had eady spoken of the speedy practicability of constructing telescopes that should magnify 4000 times, by means of which the lunar mountains might be accurately laid down.

Optical instruments of such enormous focal lengths remind us of the Arabian contrivances of measurement: quadrants with a radius of about 190 feet, upon whose graduated limb the image of the sun was received as in the gnomon, through a small round aperture. Such a quadrant was erected at Samarcand, probably constructed after the model of the older sextants of Alchokandi, which were about sixty feet in height.

LATE INVENTION OF OPTICAL INSTRUMENTS.

A writer in the *North-British Review*, No. 50, considers it strange that a variety of facts which must have presented themselves to the 'most careless observer should not have led to the earlier construction of Optical Instruments. The ancients, doubtless, must have formed metallic articles with concave surfaces, in which the observer could not fail to see himself magnified; and if the radius of the concavity exceeded twelve inches, twice the focal distance of his eye, he had in his hands an extempore reflecting telescope of the Newtonian form, in which the concave metal was the speculum, and his eye the eye-glass, and which would magnify and bring near him the image of objects nearly behind him. Through the spherical drops of water suspended before his eye, an attentive observer might have seen magnified some minute body placed accidentally in its anterior focus; and in the eyes of fishes and quadrupeds which he used for his food, he might have seen, and might have extracted, the beautiful lenses which they contain, and which he could not fail to regard as the principal agents in the vision of the animals to which they belonged. Curiosity might have prompted him to look through these remarkable lenses or spheres; and had he placed the lens of the smallest minnow, or that of the bird, the sheep, or the ox, in or before a circular aperture, he would have produced a microscope or microscopes of excellent quality and different magnifying powers. No such observations seem, however, to have been made; and even after the invention of glass, and its conversion into globular vessels, through which, when filled with any fluid, objects are magnified, the microscope remained undiscovered.

A TRIAD OF CONTEMPORARY ASTRONOMERS.

It is a remarkable fact in the history of astronomy (says Sir David Brewster), that three of its most distinguished professors were contemporaries. Galileo was the contemporary of Tycho during thirty-seven years, and of Kepler during the fifty-nine years of his life. Galileo was born seven years before

Kepler, and survived him nearly the same time. We have not learned that the intellectual triumvirate of the age enjoyed any opportunity for mutual congratulation. What a privilege would it have been to have contrasted the aristocratic dignity of Tycho with the reckless ease of Kepler, and the manly and impetuous mien of the Italian sage!—*Brewster's Life of Newton.*

A PEASANT ASTRONOMER.

At about the same time that Goodricke discovered the variation of the remarkable periodical star Algol, or β Persei, one Palitzch, a farmer of Prolitz, near Dresden,—a peasant by station, an astronomer by nature,—from his familiar acquaintance with the aspect of the heavens, was led to notice, among so many thousand stars, Algol, as distinguished from the rest by its variation, and ascertained its period. The same Palitzch was also the first to re-discover the predicted comet of Halley in 1759, which he saw nearly a month before any of the astronomers, who, armed with their telescopes, were anxiously watching its return. These anecdotes carry us back to the era of the Chaldean shepherds.—*Sir John Herschel's Outlines.*

SHIRBURN-CASTLE OBSERVATORY.

Lord Macclesfield, the eminent mathematician, who was twelve years President of the Royal Society, built at his seat, Shirburn Castle in Oxfordshire, an Observatory, about 1739. It stood 100 yards south from the castle-gate, and consisted of a bed-chamber, a room for the transit, and the third for a mural quadrant. In the possession of the Royal Astronomical Society is a curious print representing two of Lord Macclesfield's servants taking observations in the Shirburn observatory; they are Thomas Phelps, aged 82, who, from being a stable-boy to Lord-Chancellor Macclesfield, rose by his merit and genius to be appointed observer. His companion is John Bartlett, originally a shepherd, in which station he, by books and observation, acquired such a knowledge in computation, and of the heavenly bodies, as to induce Lord Macclesfield to appoint him assistant-observer in his observatory. Phelps was the person who, on December 23d, 1743, discovered the great comet, and made the first observation of it; an account of which is entered in the *Philosophical Transactions*, but not the name of the observer.

LACAILLE'S OBSERVATORY.

Lacaille, who made more observations than all his contemporaries put together, and whose researches will have the highest value as long as astronomy is cultivated, had an observatory at the Collège Mazarin, part of which is now the Palace of the Institute, at Paris.

For a long time it had been without observer or instruments; under Napoleon's reign it was demolished. Lacaille never used to illuminate the wires of his instruments. The inner part of his observatory was painted black; he admitted only the faintest light, to enable him to see his pendulum and his paper: his left eye was devoted to the service of looking to the pendulum, whilst his right eye was kept shut. The latter was only employed to look to the telescope, and during the time of observation never opened but for this purpose. Thus the faintest light made him distinguish the wires, and he very seldom felt the necessity of illuminating them. Part of these blackened walls were visible long after the demolition of the observatory, which took place somewhat about 1811.—*Professor Mohl.*

NICETY REQUIRED IN ASTRONOMICAL CALCULATIONS.

In the *Edinburgh Review*, 1850, we find the following illustrations of the enormous propagation of minute errors:

The rod used in measuring a base-line is commonly about ten feet long; and the astronomer may be said truly to apply that very rod to mete the distance of the stars. An error in placing a fine dot which fixes the length of the rod, amounting to one-five-thousandth of an inch (the thickness of a single silken fibre), will amount to an error of 70 feet in the earth's diameter, of 316 miles in the sun's distance, and to 65,200,000 miles in that of the nearest fixed star. Secondly, as the astronomer in his observatory has nothing further to do with ascertaining lengths or distances, except by calculation, his whole skill and artifice are exhausted in the measurement of angles; for by these alone spaces inaccessible can be compared. Happily, a ray of light is straight: were it not so (in celestial spaces at least), there would be an end of our astronomy. Now an angle of a second (3600 to a degree) is a subtle thing. It has an apparent breadth utterly invisible to the unassisted eye, unless accompanied with so intense a splendour (*e. g.* in the case of a fixed star) as actually to raise by its effect on the nerve of sight a spurious image having a sensible breadth. A silkworm's fibre, such as we have mentioned above, subtends an angle of a second at 3½ feet distance; a cricket-ball, 2½ inches diameter, must be removed, in order to subtend a second, to 43,000 feet, or about 8 miles, where it would be utterly invisible to the sharpest sight aided even by a telescope of some power. Yet it is on the measure of one single second that the ascertainment of a sensible parallax in any fixed star depends; and an error of one-thousandth of that amount (a quantity still unmeasurable by the most perfect of our instruments) would place the star too far or too near by 200,000,000,000 miles; a space which light requires 118 days to travel.

CAN STARS BE SEEN BY DAYLIGHT?

Aristotle maintains that Stars may occasionally be seen in the Daylight, from caverns and cisterns, as through tubes. Pliny alludes to the same circumstance, and mentions that stars have been most distinctly recognised during solar eclipses. Sir John Herschel has heard it stated by a celebrated optician, that his attention was first drawn to astronomy by the regular appearance, at a certain hour, for several successive days, of a considerable star through the shaft of a chimney. The chimney-sweepers who have been questioned upon this subject agree tolerably well in stating that "they have never seen stars by day, but that when observed at night through deep shafts, the sky appeared quite near, and the stars larger." Saussure states that stars have been seen with the naked eye in broad daylight, on the declivity of Mont Blanc, at an elevation of 12,757 feet, as he was assured by several of the alpine guides. The observer must be placed entirely in the shade, and have a thick and massive shade above his head, else the stronger light of the air will disperse the faint image of the stars; these conditions resembling those presented by the cisterns of the ancients, and the chimneys above referred to. Humboldt, however, questions the accuracy of these evidences, adding that in the Cordilleras of Mexico, Quito, and Peru, at elevations of 15,000 or 16,000 feet above the sea-level, he never could distinguish stars by daylight. Yet, under the ethereally pure sky of Cumana, in the plains near the sea-shore, Humboldt has frequently been able, after observing an eclipse of Jupiter's satellites, to find the planet again with the naked eye, and has most distinctly seen it when the sun's disc was from 18° to 20° above the horizon.

LOST HEAT OF THE SUN.

By the nature of our atmosphere, we are protected from the influence of the full flood of solar heat. The absorption of caloric by the air has been calculated at about one-fifth of the whole in passing through a column of 6000 feet, estimated near the earth's surface. And we are enabled, knowing the increasing rarity of the upper regions of our gaseous envelope, in which the absorption is constantly diminishing, to prove that *about one-third of the solar heat is lost* by vertical transmission through the whole extent of our atmosphere.—*J. D. Forbes, F.R.S.; Bakerian Lecture*, 1842.

THE LONDON MONUMENT USED AS AN OBSERVATORY.

Soon after the completion of the Monument on Fish Street Hill, by Wren, in 1677, it was used by Hooke and other members of the Royal Society for astronomical purposes, but abandoned on account of the vibrations being too great for the nicety required in their observations. Hence arose *the report that the Monument was unsafe*, which has been revived in our time; "but," says Elmes, "its scientific construction may bid defiance to the attacks of all but earthquakes for centuries to come." This vibration in lofty columns is not uncommon. Captain Smythe, in his *Cycle of Celestial Objects*, tells us, that when taking observations on the summit of Pompey's Pillar, near Alexandria, the mercury was sensibly affected by tremor, although the pillar is a solid.

Geology and Paleontology.

IDENTITY OF ASTRONOMY AND GEOLOGY.

While the Astronomer is studying the form and condition and structure of the planets, in so far as the eye and the telescope can aid him, the Geologist is investigating the form and condition and structure of the planet to which he belongs; and it is from the analogy of the earth's structure, as thus ascertained, that the astronomer is enabled to form any rational conjecture respecting the nature and constitution of the other planetary bodies. Astronomy and Geology, therefore, constitute the same science—the science of material or inorganic nature.

When the astronomer first surveys the *concavity* of the celestial vault, he finds it studded with luminous bodies differing in magnitude and lustre, some moving to the east and others to the west; while by far the greater number seem fixed in space; and it is the business of astronomers to assign to each of them its proper place and sphere, to determine their true distance from the earth, and to arrange them in systems throughout the regions of sidereal space.

In like manner, when the geologist surveys the *convexity* of his own globe, he finds its solid covering composed of rocks and beds of all shapes and kinds, lying at every possible angle, occupying every possible position, and all of them, generally speaking, at the same distance from the earth's centre. Every where we see what was deep brought into visible relation with what was superficial—what is old with what is new—what preceded life with what followed it.

Thus displayed on the surface of his globe, it becomes the business of the geologist to ascertain how these rocks came into their present places, to determine their different ages, and to fix the positions which they originally occupied, and consequently their different distances from the centre or the circumference of the earth. Raised from their original bed, the geologist must study the internal forces by which they were upheaved, and the agencies by which they were indurated; and when he finds that strata of every kind, from the primitive granite to the recent tertiary marine mud, have been thus brought within his reach, and prepared for his analysis, he reads their respective ages in the organic remains which they entomb; he studies the manner in which they have perished, and he counts the cycles of time and of life which they disclose. —*Abridged from the North-British Review*, No. 9.

THE GEOLOGY OF ENGLAND

is more interesting than that of other countries, because our island is in a great measure an epitome of the globe; and the observer who is familiar with our strata, and the fossil remains which they include, has not only prepared himself for similar inquiries in other countries, but is already, as it were, by anticipation, acquainted with what he is to find there.—*Transactions of the Geological Society.*

PROBABLE ORIGIN OF THE ENGLISH CHANNEL.

The proposed construction of a submarine tunnel across the Straits of Dover has led M. Boué, For. Mem. Geol. Soc., to point out the probability that the English Channel has not been excavated by water-action only; but owes its origin to one of the lines of disturbance which have fissured this portion of the earth's crust: and taking this view of the case, the fissure probably still exists, being merely filled with comparatively loose material, so as to prove a serious obstacle to any attempt made to drive through it a submarine tunnel.—*Proceedings of the Geological Society.*

HOW BOULDERS ARE TRANSPORTED TO GREAT HEIGHTS.

Sir Roderick Murchison has shown that in Russia, when the Dwina is at its maximum height, and penetrates into the chinks of its limestone banks, when frozen and expanded it causes disruptions of the rock, the entanglement of stony fragments in the ice. In remarkable spring floods, the stream so expands that in bursting it throws up its icy fragments to 15 or 20 feet above the stream; and the waters subsiding, these lateral ice-heaps melt away, and leave upon the bank the rifled and angular blocks as evidence of the highest ice-mark. In Lapland, M. Böhtlingk assures us that he has found *large granitic boulders weighing several tons actually entangled and suspended, like birds'-nests, in the branches of pine-trees, at heights of 30 or 40 feet above the summer level of the stream !*[*]

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[*] Mr. Hopkins supports his Glacial Theory by regarding the *Waves of Translation*, investigated by Mr. Scott Russell, as furnishing a sufficient moving power for the transportation of large rounded boulders, and the formation of drifted gravel. When these waves of translation are produced by the sudden elevation of the surface of the sea, the whole mass of water from the surface to the bottom of the ocean moves onward, and becomes a mechanical agent of enormous power. Following up this view, Mr. Hopkins has shown that "elevations of continental masses of only 50 feet each, and from beneath an ocean having a depth of between 300 and 400 feet, would cause the most powerful divergent waves, which could transport large boulders to great distances."

WHY SEA-SHELLS ARE FOUND AT GREAT HEIGHTS.

The action of subterranean forces in breaking through and elevating strata of sedimentary rocks,—of which the coast of Chili, in consequence of a great earthquake, furnishes an example,—leads to the assumption that the pelagic shells found by MM. Bonpland and Humboldt on the ridge of the Andes, at an elevation of more than 15,000 English feet, may have been conveyed to so extraordinary a position, not by a rising of the ocean, but by the agency of volcanic forces capable of elevating into ridges the softened crust of the earth.

SAND OF THE SEA AND DESERT.

That sand is an assemblage of small stones may be seen with the eye unarmed with art; yet how few are equally aware of the synonymous nature of the sand of the sea and of the land! Quartz, in the form of sand, covers almost entirely the bottom of the sea. It is spread over the banks of rivers, and forms vast plains, even at a very considerable elevation above the level of the sea, as the desert of Sahara in Africa, of Kobi in Asia, and many others. This quartz is produced, at least in part, from the disintegration of the primitive granite rocks. The currents of water carry it along, and when it is in very small, light, and rounded grains, even the wind transports it from one place to another. The hills are thus made to move like waves, and a deluge of sand frequently inundates the neighbouring countries:

> "So where o'er wide Numidian wastes extend,
> Sudden the impetuous hurricanes descend."—*Addison's Cato.*

To illustrate the trite axiom, that nothing is lost, let us glance at the most important use of sand:

"Quartz in the form of sand," observes Maltebrun, "furnishes, by fusion, one of the most useful substances we have, namely glass, which, being less hard than the crystals of quartz, can be made equally transparent, and is equally serviceable to our wants and to our pleasures. There it shines in walls of crystal in the palaces of the great, reflecting the charms of a hundred assembled beauties; there, in the hand of the philosopher, it discovers to us the worlds that revolve above us in the immensity of space, and the no less astonishing wonders that we tread beneath our feet."

PEBBLES.

The various heights and situations at which Pebbles are found have led to many erroneous conclusions as to the period of changes of the earth's surface. All the banks of rivers and lakes, and the shores of the sea, are covered with pebbles, rounded by the waves which have rolled them against each other, and which frequently seem to have brought them from a distance. There are also similar masses of pebbles found at very great elevations, to which the sea appears never to have been able to reach. We find them in the Alps at Valorsina, more than 6000 feet above the level of the sea; and on the mountain of Bon Homme, which is more than 1000 feet higher. There are some places little elevated above the level of the sea, which, like the famous plain of Crau, in Provence, are entirely paved with pebbles; while in Norway, near Quedlia, some mountains of considerable magnitude seem to be completely formed of them, and in such a manner that the largest pebbles occupy the summit, and their thickness and size diminish as you approach the base. We may include in the number of these confused and irregular heaps most of the depositions of matter brought by the river or sea, and left on the banks, and perhaps even those immense beds of sand which cover the centre of Asia and Africa. It is this circumstance which renders so uncertain the distinction, which it is nevertheless necessary to establish, between alluvial masses created before the commencement of history, and those which we see still forming under our own eyes.

A charming monograph, entitled "Thoughts on a Pebble," full of playful sentiment and graceful fancy, has been written by the amiable Dr. Mantell, the geologist.

ELEVATION OF MOUNTAIN-CHAINS.

Professor Ansted, in his *Ancient World*, thus characterises this phenomenon:

> These movements, described in a few words, were doubtless going on for many thousands and tens of thousands of revolutions of our planet. They were accompanied also by vast but slow changes of other kinds. The expansive force employed in lifting up, by mighty movements, the northern portion of the continent of Asia, found partial vent; and from partial subaqueous fissures there were poured out the tabular masses of basalt occurring in Central India; while an extensive area of depression in the Indian Ocean, marked by the coral islands of the Laccadives, the Maldives, the great Chagos bank, and some others, were in the course of depression by a counteracting movement.

Hitherto the processes of denudation and of elevation have been so far balanced as to preserve a pretty steady proportion of sea and dry land during geological ages; but if the internal temperature should be so far reduced as to be no longer capable of generating forces of expansion sufficient for this elevatory action, while the denuding forces should continue to act with unabated energy, the inevitable result would be, that every mountain-top would be in time brought low. No earthly barrier could declare to the ocean that there its proud waves should be stayed. Nothing would stop its ravages till all dry land should be laid prostrate, to form the bed over which it would continue to roll an uninterrupted sea.

THE CHALK FORMATION.

Mr. Horner, F.R.S., among other things in his researches in the Delta, considers it extremely probable that every particle of Chalk in the world has at some period been circulating in the system of a living animal.

WEAR OF BUILDING-STONES.

Professor Henry, in an account of testing the marbles used in building the Capitol at Washington, states that evrey flash of lightning produces an appreciable amount of nitric acid, which, diffused in rain-water, acts on the carbonate of lime; and from specimens subjected to actual freezing, it was found that in ten thousand years one inch would be worn from the blocks by the action of frost.

In 1839, a report of the examination of Sandstones, Limestones, and Oolites of Britain was made to the Government, with a view to the selection of the best material for building the new Houses of Parliament. For this purpose, 103 quarries were described, 96 buildings in England referred to, many chemical analyses of the stones were given, and a great number of experiments related, showing, among other points, the cohesive power of each stone, and the amount of disintegration apparent, when subjected to Brard's process. The magnesian limestone, or dolomite of Bolsover Moor, was recommended, and finally adopted for the Houses; but the selection does not appear to have been so successful as might have been expected from the skill and labour of the investigation. It may be interesting to add, that the publication of the above Report (for which see *Year-Book of Facts,* 1840, pp. 78-80) occasioned Mr John Mallcott to remark in the *Times* journal, "that all stone made use of in the immediate neighbourhood of its own quarries is more likely to endure that atmosphere than if it be removed therefrom, though only thirty or forty miles:" and the lapse of comparatively few years has proved the soundness of this observation.*

PHENOMENA OF GLACIERS ILLUSTRATED.

Professor Tyndall, being desirous of investigating some of the phenomena presented by the large masses of mountain-ice,—those frozen rivers called Glaciers,—devised the plan of sending a destructive agent into the midst of a mass of ice, so as to break down its structure in the interior, in order to see if this method would reveal any thing of its internal constitution. Taking advantage of the bright weather of 1857, he concentrated a beam of sunlight by a condensing lens, so as to form the focus of the sun's rays in the midst of a mass of ice. A portion of the ice was melted, but the surrounding parts shone out as brilliant stars, produced by the reflection of the faces of the crystalline structure. On examining these brilliant portions with a lens, Professor Tyndall discovered that the structure of the ice had been broken down in symmetrical forms of great beauty, presenting minute stars, surrounded by six petals, forming a beautiful flower, the plane being always parallel to the plane of congelation of the ice. He then prepared a piece of ice, by making both its surfaces smooth and parallel to each other. He concentrated in the centre of the ice the rays of heat from the electric light; and then, placing the piece of ice in the electric microscope, the disc revealed these beautiful ice-flowers.

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* It is scarcely too much to say, that from the collection of specimens of building-stones made upon this occasion, and first deposited in a house in Craig's Court, Charing Cross, originated, upon the suggestion of Sir Henry Delabeche, the magnificent Museum of Practical Geology in Jermyn Street, one of the most eminently practical institutions of this scientific age.

A mass of ice was crushed into fragments; the small fragments were then placed in a cup of wood; a hollow wooden die, somewhat smaller than the cup, was then pressed into the cup of ice-fragments by the pressure of a hydraulic press, and the ice-fragments were immediately united into a compact cup of nearly transparent ice. This pressure of fragments of ice into a solid mass explains the formation of the glaciers and their origin. They are composed of particles of ice or snow; as they descend the sides of the mountain, the pressure of the snow becomes sufficiently great to compress the mass into solid ice, until it becomes so great as to form the beautiful blue ice of the glaciers. This compression, however, will not form the solid mass unless the temperature of the ice be near that of freezing water. To prove this, the lecturer cooled a mass of ice, by wrapping it in a piece of tinfoil and exposing it for some time to a bath of the ethereal solution of solidified carbonic-acid gas, the coldest freezing mixture known. This cooled mass of ice was crushed to fragments, and submitted to the same pressure which the other fragments had been exposed to without cohering in the slightest degree.—*Lecture at the Royal Institution*, 1858.

ANTIQUITY OF GLACIERS.

The importance of glacier agency in the past as well as the present condition of the earth, is undoubtedly very great. One of our most accomplished and ingenious geologists has, indeed, carried back the existence of Glaciers to an epoch of dim antiquity, even in the reckoning of that science whose chronology is counted in millions of years. Professor Ramsay has shown ground for believing that in the fragments of rock that go to make up the conglomerates of the Permian strata, intermediate between the Old and the New Red Sandstone, there is still preserved a record of the action of ice, either in glaciers or floating icebergs, before those strata were consolidated.—*Saturday Review*, No. 142.

FLOW OF THE MER DE GLACE.

Michel Devouasson of Chamouni fell into a crevasse on the Glacier of Talefre, a feeder of the Mer de Glace, on the 29th of July 1836, and after a severe struggle extricated himself, leaving his knapsack below. The identical knapsack reappeared in July 1846, at a spot on the surface of the glacier *four thousand three hundred* feet from the place where it was lost, as ascertained by Professor Forbes, who himself collected the fragments; thus indicating the rate of flow of the icy river in the intervening ten years.—*Quarterly Review*, No. 202.

THE ALLUVIAL LAND OF EGYPT : ANCIENT POTTERY.

Mr. L. Horner, in his recent researches near Cairo, with the view of throwing light upon the geological history of the alluvial land of Egypt, obtained from the lowest part of the boring of the sediment at the colossal statue of Rameses, at a depth of thirty-nine feet, this curious relic of the ancient world; the boring instrument bringing up a fragment of pottery about an inch square and a quarter of an inch in thickness—the two surfaces being of a brick-red colour, the interior dark gray. According to Mr. Horner's deductions, this fragment, having been found at a depth of 39 feet (if there be no fallacy in his reasoning), must be held to be a record of the existence of man 13,375 years before A.D. 1858, reckoning by the calculated rate of increase of three inches and a half of alluvium in a century —11,517 years before the Christian era, and 7625 before the beginning assigned by Lepsius to the reign of Menos, the founder of Memphis. Moreover it proves in his opinion, that man had already reached a state of civilisation, so far at least as to be able to fashion clay into vessels, and to know how to harden it by the action of strong heat. This calculation is supported by the Chevalier Bunsen, who is of opinion that the first epochs of the history of the human race demand at the least a period of 20,000 years before our era as a fair starting-point in the earth's history.—*Proceedings of Royal Soc.*, 1858.

Upon this theory, a Correspondent, "An Old Indigo-Planter," writes to the *Athenæum*, No. 1509, the following suggestive note: "Having lived many years on the banks of the Ganges, I have seen the stream encroach on a village, undermining the bank where it stood, and deposit, as a natural result, bricks, pottery, &c. in the bottom of the stream. On one occasion, I am certain that the depth of the stream where the bank was breaking was above 40 feet; yet in three years the current of the river drifted so much, that a fresh deposit of soil took place over the *débris* of the village, and the earth was raised to a level with the old bank. Now had our traveller then obtained a bit of pottery from where it had lain for only three years, could he reasonably draw the inference that it had been made 13,000 years before?"

SUCCESSIVE CHANGES OF THE TEMPLE OF SERAPIS.

The Temple of Serapis at Puzzuoli, near Naples, is perhaps, of all the structures raised by the hands of man, the one which affords most instruction to a geologist. It has not only undergone a wonderful succession of changes in past time, but is still undergoing changes of condition. This edifice was exhumed in 1750 from the eastern shore of the Bay of Baiæ, consisting partly of strata containing marine shells with fragments of pottery and sculpture, and partly of volcanic matter of sub-aerial origin. Various theories were proposed in the last century to explain the perforations and attached animals observed on the middle zone of the three erect marble columns until recently standing; Goethe, among the rest, suggesting that a lagoon had once existed in the vestibule of the temple, filled during a temporary incursion of the sea with salt water, and that marine mollusca and annelids flourished for years in this lagoon at twelve feet or more above the sea-level.

This hypothesis was advanced at a time when almost any amount of fluctuation in the level of the sea was thought more probable than the slightest alteration in the level of the solid land. In 1807 the architect Niccolini observed that the pavement of the temple was dry, except when a violent south wind was blowing; whereas, on revisiting the temple fifteen years later, he found the pavement covered by salt water twice every day at high tide. From measurements made from 1822 to 1838, and thence to 1845, he inferred that the sea was gaining annually upon the floor of the temple at the rate of about one-third of an inch during the first period, and about three-fourths of an inch during the second. Mr. Smith of Jordan Hill, from his visits in 1819 and 1845, found an average rise of about an inch annually, which was in accordance with visits made by Mr. Babbage in 1828, and Professor James Forbes in 1826 and 1843. In 1852 Signor Scaecchi, at the request of Sir Charles Lyell, compared the depth of water on the pavement with its level taken by him in 1839, and found that it had gained only 4½ inches in thirteen years, and was not so deep as when MM. Niccolini and Smith measured it in 1845; from which he inferred that after 1845 the downward movement of the land had ceased, and before 1852 had been converted into an upward movement.

Arago and others maintained that the surface on which the temple stands has been depressed, has *remained under the sea, and has again been elevated.* Russager, however, contends that there is nothing in the vicinity of the temple, or in the temple itself, to justify this bold hypothesis. Every thing leads to the belief that the temple has remained unchanged in the position in which it was originally built; but that the sea rose, surrounded it to a height of at least twelve feet, and again retired; but the elevated position of the sea continued sufficiently long to admit of the animals boring the pillars. This view can even be proved historically; for Niccolini, in a memoir published in 1840, gives the heights of the level of the sea in the Bay of Naples for a period of 1900 years, and has with much acuteness proved his assertions historically. The correctness of Russager's opinion, he states, can be demonstrated and reduced to figures by means of the dates collected by Niccolini. —See *Jameson's Journal*, No. 58.

At the present time the floor is always covered with sea-water. On the whole, there is little doubt that the ground has sunk upwards of two feet during the last half-century. This gradual subsidence confirms in a remarkable manner Mr. Babbage's conclusions—drawn from the calcareous incrustations formed by the hot springs on the walls of the building and from the ancient lines of the water-level at the base of the three columns —that the original subsidence was not sudden, but slow and by successive movements.

Sir Charles Lyell (who, in his *Principles of Geology*, has given a detailed account of the several upfillings of the temple) considers that when the mosaic pavement was re-constructed, the floor of the building must have stood about twelve feet above the level of 1838 (or about 11½ feet above the level of the sea), and that it had sunk about nineteen feet below that level before it was elevated by the eruption of Monte Nuovo.

We regret to add, that the columns of the temple are no longer in the position in which they served so many years as a species of self-registering hydrometer: the materials have been newly arranged, and thus has been torn as it were from history a page which can never be replaced.

THE GROTTO DEL CANE.

This "Dog Grotto" has been so much cited for its stratum of carbonic-acid gas covering the floor, that all geological travellers who visit Naples feel an interest in seeing the wonder.

This cavern was known to Pliny. It is continually exhaling from its sides and floor volumes of steam mixed with carbonic-acid gas; but the latter, from its greater specific gravity, accumulates at the bottom, and flows over the step of the door. The upper part of the cave, therefore, is free from the gas, while the floor is completely covered by it. Addison, on his visit, made some interesting experiments. He found that a pistol could not be fired at the bottom; and that on laying a train of gunpowder and igniting it on the outside of the cavern, the carbonic-acid gas "could not intercept the train of fire when it once began flashing, nor hinder it from running to the very end." He found that a viper was nine minutes in dying on the first trial, and ten minutes on the second; this increased vitality being, in his opinion, attributable to the stock of air which it had inhaled after the first trial. Dr. Daubeny found that phosphorus would continue lighted at about two feet above the bottom; that a sulphur-match went out in a few minutes above it, and a wax-taper at a still higher level. The keeper of the cavern has a dog, upon which he shows the effects of the gas, which, however, are quite as well, if not better, seen in a torch, a lighted candle, or a pistol.

"Unfortunately," says Professor Silliman, "like some other grottoes, the enchantment of the 'Dog Grotto' disappears on a near view." It is a little hole dug artificially in the side of a hill facing Lake Agnano: it is scarcely high enough for a person to stand upright in, and the aperture is closed by a door. Into this narrow cell a poor little dog is very unwillingly dragged and placed in a depression of the floor, where he is soon narcotised by the carbonic acid. The earth is warm to the hand, and the gas given out is very constant.

THE WATERS OF THE GLOBE GRADUALLY DECREASING.

This was maintained by M. Bory Saint Vincent, because the vast deserts of sand, mixed up with the salt and remains of marine animals, of which the surface of the globe is partly composed, were formerly inland seas, which have insensibly become dry. The Caspian, the Dead Sea, the Lake Baikal, &c. will become dry in their turn also, when their beds will be sandy deserts. The inland seas, whether they have only one outlet, as the Mediterranean, the Red Sea, the Baltic, &c., or whether they have several, as the Gulf of Mexico, the seas of O'Kotsk, of Japan, China, &c., will at some future time cease to communicate with the great basins of the ocean; they will become inland seas, true Caspians, and in due time will become likewise dry. On all sides the waters of rivers are seen to carry forward in their course the soil of the continent. Alluvial lands, deltas, banks of sand, form themselves near the coasts, and in the directions of the currents; madreporic animals lay the foundations of new lands; and while the straits become closed, while the depths of the sea fill up, the level of the sea, which it would seem natural should become higher, is sensibly lower. There is, therefore, an actual diminution of liquid matter.

THE SALT LAKE OF UTAH.

Lieutenant Gunnison, who has surveyed the great basin of the Salt Lake, states the water to be about one-third salt, which it yields on boiling. Its density is considerably greater than that of the Red Sea. One can hardly get the whole body below the surface: in a sitting position the head and shoulders will remain above the water, such is the strength of the brine; and on coming to the shore the body is covered with an incrustation of salt in fine crystals. During summer the lake throws on shore abundance of salt, while in winter it throws up Glauber salt plentifully. "The reason of this," says Lieutenant Gunnison, "is left for the scientific to judge, and also what becomes of the enormous amount of fresh water poured into it by three or four large rivers,—Jordan, Bear, and Weber,—as there is no visible effect."

FORCE OF RUNNING WATER.

It has been proved by experiment that the rapidity at the bottom of a stream is every where less than in any other part of it, and is greatest at the surface. Also, that in the middle of the stream the particles at the top move swifter than those at the sides. This slowness of the lowest and side currents is produced by friction; and when the rapidity is sufficiently great, the soil composing the sides and bottom gives way. If the water flows at the rate of three inches per second, it will tear up fine clay; six inches per second, fine sand; twelve inches per second, fine gravel; and three feet per second, stones the size of an egg.—*Sir Charles Lyell.*

THE ARTESIAN WELL OF GRENELLE AT PARIS.

M. Peligot has ascertained that the Water of the Artesian Well of Grenelle contains not the least trace of air. Subterranean waters ought therefore to be *aerated* before being used as aliment. Accordingly, at Grenelle, has been constructed a tower, from the top of which the water descends in innumerable threads, so as to present as much surface as possible to the air.

The boring of this Well by the Messrs. Mulot occupied seven years, one month, twenty-six days, to the depth of 1794½ English feet, or 194½ feet below the depth at which M. Elie de Beaumont foretold that water would be found. The sound, or borer, weighed 20,000 lb., and was treble the height of that of the dome of the Hôpital des Invalides at Paris. In May 1837, when the bore had reached 1246 feet 8 inches, the great chisel and 262 feet of rods fell to the bottom; and although these weighed five tons, M. Mulot tapped a screw on the head of the rods, and thus, connecting another length to them, after fifteen months' labour, drew up the chisel. On another occasion, this chisel having been raised with great force, sank at one stroke 85 feet 3 inches into the chalk!

The depth of the Grenelle Well is nearly four times the height of Strasburg Cathedral; more than six times the height of the Hôpital des Invalides at Paris; more than four times the height of St. Peter's at Rome; nearly four times and a half the height of St. Paul's, and nine times the height of the Monument, London. Lastly, suppose all the above edifices to be piled one upon each other, from the base-line of the Well of Grenelle, and they would but reach within 11½ feet of its surface.

MM. Elie de Beaumont and Arago never for a moment doubted the final success of the work; their confidence being based on analogy, and on a complete acquaintance with the geological structure of the Paris basin, which is identical with that of the London basin beneath the London clay.

In the duchy of Luxembourg is a well the depth of which surpasses all others of the kind. It is upwards of 1000 feet more than that of Grenelle near Paris.

HOW THE GULF-STREAM REGULATES THE TEMPERATURE OF LONDON.

Great Britain is almost exactly under the same latitude as Labrador, a region of ice and snow. Apparently, the chief cause of the remarkable difference between the two climates arises from the action of the great oceanic Gulf-Stream, whereby this country is kept constantly encircled with waters warmed by a West-Indian sun.

Were it not for this unceasing current from tropical seas, London, instead of its present moderate average winter temperature of 6° above the freezing-point, might for many months annually be ice-bound by a settled cold of 10° to 30° below that point, and have its pleasant summer months replaced by a season so short as not to allow corn to ripen, or only an alpine vegetation to flourish.

Nor are we without evidence afforded by animal life of a greater cold having prevailed in this country at a late geological period. One case in particular occurs within eighty miles of London, at the village of Chillesford, near Woodbridge, where, in a bed of clayey sand of an age but little (geologically speaking) anterior to the London gravel, Mr. Prestwich has found a group of fossil shells in greater part identical with species now living in the seas of Greenland and of similar latitudes, and which must evidently, from their perfect condition and natural position, have existed in the place where they are now met with.—*Lectures on the Geology of Clapham, &c. by Joseph Prestwich, A.R.S., F.G.S.*

SOLVENT ACTION OF COMMON SALT AT HIGH TEMPERATURES.

Forchhammer, after a long series of experiments, has come o the conclusion that Common Salt at high temperatures, such s prevailed at earlier periods of the earth's history, acted as general solvent, similarly to water at common temperatures. he amount of common salt in the earth would suffice to cover ts whole surface with a crust ten feet in thickness.

FREEZING CAVERN IN RUSSIA.

This famous Cavern, at Ithetz Kaya-Zastchita, in the Steppes of the Kirghis, is employed by the inhabitants as a cellar. It has the very remarkable property of being so intensely cold during the hottest summers as to be then filled with ice, which disappearing with cold weather, is entirely gone in winter, when all the country is clad in snow. The roof is hung with ever-dripping solid icicles, and the floor may be called a stalagmite of ice and frozen earth. "If," says Sir R. Murchison, "as we were assured, *the cold is greatest when the external air is hottest and driest*, that the fall of rain and a moist atmosphere produce some diminution of the cold in the cave, and that upon the setting-in of winter the ice disappears entirely,—then indeed the problem is very curious." The peasants assert that in winter they could sleep in the cave without their sheepskins.

INTERIOR TEMPERATURE OF THE EARTH: CENTRAL HEAT.

By the observed temperature of mines, and that at the bottom of artesian wells, it has been established that the rate at which such temperature increases as we descend varies considerably in different localities, where the depths are comparatively small; but where the depths are great, we find a much nearer approximation to a common rate of increase, which, as determined by the best observation in the deepest mines, shafts, and artesian wells in Western Europe, is very nearly 1° F. *for an increase in depth of fifty feet.—W. Hopkins, M.A., F.R.S.*

Humboldt states that, according to tolerably coincident experiments in artesian wells, it has been shown that the heat increases on an average about 1° for every 54·5 feet. If this increase can be reduced to arithmetical relations, it will follow that a stratum of granite would be in a state of fusion at a depth of nearly twenty-one geographical miles, or between four and five times the elevation of the highest summit of the Himalaya.

The following is the opinion of Professor Silliman:

> That the whole interior portion of the earth, or at least a great part of it, is an ocean of melted rock, agitated by violent winds, though I dare not affirm it, is still rendered highly probable by the phenomena of volcanoes. The facts connected with their eruption have been ascertained and placed beyond a doubt. How, then, are they to be accounted for? The theory prevalent some years since, that they are caused by the combustion of immense coal-beds, is puerile and now entirely abandoned. All the coal in the world could not afford fuel enough for one of the tremendous eruptions of Vesuvius.

This observed increase of temperature in descending beneath the earth's surface suggested the notion of a central incandescent nucleus still remaining in a state of fluidity from its elevated temperature. Hence the theory that the whole mass of the earth was formerly a molten fluid mass, the exterior portion of which, to some unknown depth, has assumed its present solidity by the radiation of heat into surrounding space, and its consequent refrigeration.

The mathematical solution of this problem of Central Heat, assuming such heat to exist, tells us that though the central portion of the earth may consist of a mass of molten matter, the temperature of its surface is not thereby increased by more than the small fraction of a degree. Poisson has calculated that it would require *a thousand millions of centuries* to reduce this fraction to a degree by half its present amount, supposing always the external conditions to remain unaltered. In such cases, the superficial temperature of the earth may, in fact, be considered to have approximated so near to its ultimate limit that it can be subject to no further sensible change.

DISAPPEARANCE OF VOLCANIC ISLANDS.

Many of the Volcanic Islands thrown up above the sea-level soon disappear, because the lavas and conglomerates of which they are formed spread over flatter surfaces, through the weight of the incumbent fluid; and the constant levelling process goes on below the sea by the action of tides and currents. Such islands as have effectually resisted this action are found to possess a solid framework of lava, supporting or defending the loose fragmentary materials.

Among the most celebrated of these phenomena in our times may be mentioned the Isle of Sabrina, which rose off the coast of St. Michael's in 1811, attained a circumference of one mile and a height of 300 feet, and disappeared in less than eight months; in the following year there were eighty fathoms of water in its place. In July 1831 appeared Graham's Island off the coast of Sicily, which attained a mile in circumference and 150 or 160 feet in height; its formation much resembled that of Sabrina.

The line of ancient subterranean fire which we trace on the Mediterranean coasts has had a strange attestation in Graham's Island, which is also described as a volcano suddenly bursting forth in the mid-sea between Sicily and Africa; burning for several weeks, and throwing up an isle, or crater-cone of scoriæ and ashes, which had scarcely been named before it was again lost by subsidence beneath the sea, leaving only a shoal-bank to attest this strange submarine breach in the earth's crust, which thus mingled fire and water in one common action.

Floating islands are not very rare: in 1827, one was seen twenty leagues to the east of the Azores; it was three leagues in width, and covered with volcanic products, sugar-canes, straw, and pieces of wood.

PERPETUAL FIRE.

Not far from the Deliktash, on the side of a mountain in Lycia, is the Perpetual Fire described some forty years since by Captain Beaufort. It was found by Lieutenant Spratt and Professor Forbes, thirty years later, as brilliant as ever, and somewhat increased; for besides the large flame in the corner of the ruins described by Beaufort, there were small jets issuing from crevices in the side of the crater-like cavity five or six feet deep. At the bottom was a shallow pool of sulphureous and turbid water, regarded by the Turks as a sovereign remedy for all skin complaints. The soot deposited from the flames was held to be efficacious for sore eyelids, and valued as a dye for the eyebrows. This phenomenon is described by Pliny as the flame of the Lycian Chimera.

ARTESIAN FIRE-SPRINGS IN CHINA.

According to the statement of the missionary Imbert, the Fire-Springs, "Ho-tsing" of the Chinese, which are sunk to obtain a carburetted-hydrogen gas for salt-boiling, far exceed our artesian springs in depth. These springs are very commonly more than 2000 feet deep; and a spring of continued flow was found to be 3197 feet deep. This natural gas has been used in the Chinese province Tse-tschuan for several thousand years; and "portable gas" (in bamboo-canes) has for ages been used in the city of Khiung-tscheu. More recently, in the village of Fredonia, in the United States, such gas has been used both for cooking and for illumination.

VOLCANIC ACTION THE GREAT AGENT OF GEOLOGICAL CHANGE.

Mr. James Nasmyth observes, that "the floods of molten lava which volcanoes eject are nothing less than remaining portions of what was once the condition of the entire globe when in the igneous state of its early physical history,—no one knows how many years ago!

"When we behold the glow and feel the heat of molten lava, how vastly does it add to the interest of the sight when we consider that the heat we feel and the light we see are the residue of the once universal condition of our entire globe, on whose *cooled surface* we *now* live and have our being! But so it is; for if there be one great fact which geological research has established beyond all doubt, it is that we reside on the cooled surface of what was once a molten globe, and that all the phenomena which geology has brought to light can be most satisfactorily traced to the successive changes incidental to its gradual cooling and contraction.

"That the influx of the sea into the yet hot and molten interior of the globe may occasionally occur, and enhance and vary the violence of the phenomenon of volcanic action, there can be little doubt; but the action of water in such cases is only *secondary*. But for the pre-existing high temperature of the interior of the earth, the influx of water would produce no such discharges of molten lava as generally characterise volcanic eruptions. Molten lava is therefore a true vestige of the Natural History of the Creation."

THE SNOW-CAPPED VOLCANO.

It is but rarely that the elastic forces at work within the interior of our globe have succeeded in breaking through the spiral domes which, resplendent in the brightness of eternal snow, crown the summits of the Cordilleras; and even where these subterranean forces have opened a permanent communication with the atmosphere, through circular craters or long fissures, they rarely send forth currents of lava, but merely eject ignited scoriæ, steam, sulphuretted hydrogen gas, and jets of carbonic acid.—*Humboldt's Cosmos*, vol. i.

TRAVELS OF VOLCANIC DUST.

On the 2d of September 1845, a quantity of Volcanic Dust fell in the Orkney Islands, which was supposed to have originated in an eruption of Hecla, in Iceland. It was subsequently ascertained that an eruption of that volcano took place on the morning of the above day (September 2), so as to leave no doubt of the accuracy of the conclusion. The dust had thus travelled about 600 miles!

GREAT ERUPTIONS OF VESUVIUS.

In the great eruption of Vesuvius, in August 1779, which Sir William Hamilton witnessed from his villa at Pausilippo in the bay of Naples, the volcano sent up white sulphureous smoke resembling bales of cotton, exceeding the height and size of the mountain itself at least four times; and in the midst of this vast pile of smoke, stones, scoriæ, and ashes were thrown up not less than 2000 feet. Next day a fountain of fire shot up with such height and brilliancy that the smallest objects could be clearly distinguished at any place within six miles or more of Vesuvius. But on the following day a more stupendous column of fire rose three times the height of Vesuvius (3700 feet), or more than two miles high. Among the huge fragments of lava thrown out during this eruption was a block 108 feet in circumference and 17 feet high, another block 66 feet in circumference and 19 feet high, and another 16 feet high and 92 feet in circumference, besides thousands of smaller fragments. Sir William Hamilton suggests that from a scene of the above kind the ancient poets took their ideas of the giants waging war with Jupiter.

The eruption of June 1794, which destroyed the greater part of the town of Torre del Greco, was, however, the most violent that has been recorded after the two great eruptions of 79 and 1631.

EARTH-WAVES.

The waves of an earthquake have been represented in their progress, and their propagation, through rocks of different density and elasticity; and the causes of the rapidity of propagation, and its diminution by the refraction, reflection, and interference of the oscillations have been mathematically investigated. Air, water, and earth waves follow the same laws which are recognised by the theory of motion, at all events in space; but the earth-waves are accompanied in their destructive action by discharges of elastic vapours, and of gases, and mixtures of pyroxene crystals, carbon, and infusorial animalcules with silicious shields. The more terrific effects are, however, when the earth-waves are accompanied by cleavage; and, as in the earthquake of Riobamba, when fissures alternately opened and closed again, so that men saved themselves by extending both arms, in order to prevent their sinking.

As a remarkable example of the closing of a fissure, Humboldt mentions that, during the celebrated earthquake in 1851, in the Neapolitan province of Basilicata, a hen was found caught by both feet in the street-pavement of Barile, near Melfi.

Mr. Hopkins has very correctly shown theoretically that the fissures produced by earthquakes are very instructive as regards the formation of veins and the phenomenon of dislocation, the more recent vein displacing the older formation.

RUMBLINGS OF EARTHQUAKES.

When the great earthquake of Coseguina, in Nicaragua, took place, January 23, 1835, the subterranean noise—the sonorous waves in the earth—was heard at the same time on the island of Jamaica and on the plateau of Bogota, 8740 feet above the sea, at a greater distance than from Algiers to London. In the eruptions of the volcano on the island of St. Vincent, April 30, 1812, at 2 A.M., a noise like the report of cannons was heard, without any sensible concussion of the earth, over a space of 160,000 geographical square miles. There have also been heard subterranean thunderings for two years without earthquakes.

HOW TO MEASURE AN EARTHQUAKE-SHOCK.

A new instrument (the Seismometer) invented for this purpose by M. Kreil, of Vienna, consists of a pendulum oscillating in every direction, but unable to turn round on its point of suspension; and bearing at its extremity a cylinder, which, by means of mechanism within it, turns on its vertical axis once in twenty-four hours. Next to the pendulum stands a rod bearing a narrow elastic arm, which slightly presses the extremity of a lead-pencil against the surface of the cylinder. As long as the pendulum is quiet, the pencil traces an uninterrupted line on the surface of the cylinder; but as soon as it oscillates, this line becomes interrupted and irregular, and these irregularities indicate the time of the commencement of an earthquake, together with its duration and intensity.*

Elastic fluids are doubtless the cause of the slight and perfectly harmless trembling of the earth's surface, which has often continued for several days. The focus of this destructive agent, the seat of the moving force, lies far below the earth's surface; but we know as little of the extent of this depth as we know of the chemical nature of these vapours that are so highly compressed. At the edges of two craters,—Vesuvius and the towering rock which projects beyond the great abyss of Pichincha, near Quito,—Humboldt has felt periodic and very regular shocks of earthquakes, on each occasion from twenty to thirty seconds before the burning scoriæ or gases were erupted. The intensity of the shocks was increased in proportion to the time intervening between them, and consequently to the length of time in which the vapours were accumulating. This simple fact, which has been attested by the evidence of so many travellers, furnishes us with a general solution of the phenomenon, in showing that active volcanoes are to be considered as safety-valves for the immediate neighbourhood. There are instances in which the earth has been shaken for many successive days in the chain of the Andes, in South America. In certain districts, the inhabitants take no more notice of the number of earthquakes than we in Europe take of showers of rain; yet in such a district Bonpland and Humboldt were compelled to dismount, from the restiveness of their mules, because the earth shook in a forest for fifteen to eighteen minutes *without intermission.*

EARTHQUAKES AND THE MOON.

From a careful discussion of several thousand earthquakes which have been recorded between 1801 and 1850, and a comparison of the periods at which they occurred with the position of the moon in relation to the earth, M. Perry, of Dijon, infers that earthquakes may possibly be the result of attraction exerted by that body on the supposed fluid centre of our globe, somewhat similar to that which she exercises on the waters of the ocean; and the Committee of the Institute of France have reported favourably upon this theory.

THE GREAT EARTHQUAKE OF LISBON.

The eloquent Humboldt remarks, that the activity of an igneous mountain, however terrific and picturesque the spectacle may be which it presents to our contemplation, is always limited to a very small space. It is far otherwise with earthquakes, which, although scarcely perceptible to the eye, nevertheless simultaneously propagate their waves to a distance of many thousand miles. The great earthquake which destroyed the city of Lisbon, November 1st, 1755, was felt in the Alps, on the coast of Sweden, into the Antilles, Antigua, Barbadoes, and Martinique; in the great Canadian lakes, in Thuringia, in the flat country of northern Germany, and in the small inland lakes on the shores of the Baltic. Remote springs were interrupted in their flow,—a phenomenon attending earthquakes which had been noticed among the ancients by Demetrius the Callatian. The hot springs of Töplitz dried up and returned, inundating every thing around, and having their waters coloured with iron ochre. At Cadiz, the sea rose to an elevation of sixty-four feet; while in the Antilles, where the tide usually rises only from twenty-six to twenty-eight inches, it suddenly rose about twenty feet, the water being of an inky blackness. It has been computed that, on November 1st, 1755, a portion of the earth's surface four times greater than that of Europe was simultaneously shaken.* As yet there is no manifestation of force known to us (says the vivid denunciation of the philosopher), including even the murderous invention of our own race, by which a greater number of people have been killed in the short space of a few minutes: 60,000 were destroyed in Sicily in 1693, from 30,000 to 40,000 in the earthquake of Riobamba in 1797, and probably five times as many in Asia Minor and Syria under Tiberius and Justinian the elder, about the years 19 and 526.

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* Mr. R. Mallet, F.R S., and his son Dr. Mallet, have constructed a seismographic map of the world, with seismic bands in their position and relative intensity; and small black discs to denote volcanoes, femaroles, and soltataras, and shades indicating the areas of subsidence.

GEOLOGICAL AGE OF THE DIAMOND.

The discovery of Diamonds in Russia, far from the tropical zone, has excited much interest among geologists. In the detritus on the banks of the Adolfskoi, no fewer than forty diamonds have been found in the gold alluvium, only twenty feet above the stratum in which the remains of mammoths and rhinoceroses are found. Hence Humboldt has concluded that the formation of gold-veins, and consequently of diamonds, is comparatively of recent date, and scarcely anterior to the destruction of the mammoths. Sir Roderick Murchison and M. Ver-

* It has been computed that the shock of this earthquake pervaded an area of 700,000 miles, or the twelfth part of the circumference of the globe. This dreadful shock lasted only five minutes; and nearly the whole of the population being within the churches (on the feast of All Saints), no less than 30,000 persons perished by the fall of these edifices.—See *Daubeny on Volcanoes; Translator's note, Humboldt's Cosmos.*

neuil have been led to the same result by different arguments.*

WHAT WAS ADAMANT?

Professor Tennant replies, that the Adamant described by Pliny was a sapphire, as proved by its form, and by the fact that when struck on an anvil by a hammer it would make an indentation in the metal. A true diamond, under such circumstances, would fly into a thousand pieces.

WHAT IS COAL?

The whole evidence we possess as to the nature of Coal proves it to have been originally a mass of vegetable matter. Its microscopical characters point to its having been formed on the spot in which we find it, to its being composed of vegetable tissues of various kinds, separated and changed by maceration, pressure, and chemical action, and to the introduction of its earthy matter, in a large number of instances, in a state of solution or fine molecular subdivision. Dr. Redfern, from whose communication to the British Association we quote, knows nothing to countenance the supposition that our coal-beds are mainly formed of coniferous wood, because the structures found in mother-coal, or the charcoal layer, have not the character of the glandular tissue of such wood, as has been asserted.

Geological research has shown that the immense forests from which our coal is formed teemed with life. A frog as large as an ox existed in the swamps, and the existence of insects proves that the higher order of organic creation flourished at this epoch.

It has been calculated that the available coal-beds in Lancashire amount in weight to the enormous sum of 8,400,000,000 tons. The total annual consumption of this coal, it has been estimated, amounts to 3,400,120 tons; hence it is inferred that the coal-beds of Lancashire, at the present rate of consumption, will last 2470 years. Making similar calculations for the coal-fields of South Wales, the north of England, and Scotland, it will readily be perceived how ridiculous were the forebodings which lecturing geologists delighted to indulge in a few years ago.

TORBANE-HILL COAL.

The coal of Torbane Hill, Scotland, is so highly inflammable, that it has been disputed at law whether it be true coal, or only asphaltum, or bitumen. Dr. Redfern describes it as laminated, splitting with great ease horizontally, like many cannel coals, and like them it may be lighted at a candle. In all parts of the bed stigmaria and other fossil plants occur in greater numbers than in most other coals; their distinct vascular tissue may be easily recognised by a common pocket lens, and 65½ of the mass consists of carbon.

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* Mr. Murray mentions, on the authority of the Rev. Dr. Robinson, of the Observatory at Armagh, that a rough diamond with a red tint, and valued by Mr Rundell at twenty guineas, was found in Ireland, many years since, in the bed of a brook flowing through the county of Fermanagh.

Dr. Redfern considers that all our coals may be arranged in a scale having the Torbane-Hill coal at the top and anthracite at the bottom. Anthracite is almost pure carbon; Torbane Hill contains less fixed carbon than most other cannels: anthracite is very difficult to ignite, and gives out scarcely any gas; Torbane-Hill burns like a candle, and yields 3000 cubic feet of gas per ton, more than any other known coal, its gas being also of greatly superior illuminating power to any other. The only differences which the Torbane-Hill coal presents from others are differences of degree, not of kind. It differs from other coals in being the best gas-coal, and from other cannels in being the best cannel.

HOW MALACHITE IS FORMED.

The rich copper-ore of the Ural, which occurs in veins or masses, amid metamorphic strata associated with igneous rocks, and even in the hollows between the eruptive rocks, is worked in shafts. At the bottom of one of these, 280 feet deep, has been found an enormous irregularly-shaped botryoidal mass of *Malachite* (Greek *malache*, mountain-green), sending off strings of green copper-ore. The upper surface of it is about 18 feet long and 9 wide; and it was estimated to contain 15,000 poods, or half a million pounds, of pure and compact malachite. Sir Roderick Murchison is of opinion that this wonderful subterraneous incrustation has been produced in the stalagmitic form, during a series of ages, by copper solutions emanating from the surrounding loose and sporous mass, and trickling through it to the lowest cavity upon the subjacent solid rock. Malachite is brought chiefly from one mine in Siberia; its value as raw material is nearly one-fourth that of the same weight of pure silver, or in a manufactured state three guineas per pound avoirdupois.[*]

LUMPS OF GOLD IN SIBERIA.

The gold mines south of Miask are chiefly remarkable for the large lumps or *pepites* of gold which are found around the Zavod of Zarevo-Alexandroisk. Previous to 1841 were discovered here lumps of native gold; in that year a lump of twenty-four pounds was met with; and in 1843 a lump weighing about seventy-eight pounds English was found, and is now deposited with others in the Museum of the Imperial School of Mines at St. Petersburg.

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[*] The use of malachite in ornamental work is very extensive in Russia. Thus, to the Great Exhibition of 1851 were sent a pair of folding-doors veneered with malachite, 13 feet high, valued at 6000*l.*; malachite cases and pedestals from 1500*l.* to 3000*l.* a-piece, malachite tables 400*l.*, and chairs 150*l.* each.

SIR ISAAC NEWTON UPON BURNET'S THEORY OF THE EARTH.

In 1668, Dr. Thomas Burnet printed his *Theoria Telluris Sacra*, "an eloquent physico-theological romance," says Sir David Brewster, "which was to a certain extent adopted even by Newton, Burnet's friend. Abandoning, as some of the fathers had done, the hexaëmeron, or six days of Moses, as a physical reality, and having no knowledge of geological phenomena, he gives loose reins to his imagination, combining passages of Scripture with those of ancient authors, and presumptuously describing the future catastrophes to which the earth is to be exposed." Previous to its publication, Burnet presented a copy of his book to Newton, and requested his opinion of the theory which it propounded. Newton took "exceptions to particular passages," and a correspondence ensued. In one of Newton's letters he treats of the formation of the earth, and the other planets, out of a general chaos of the figure assumed by the earth,—of the length of the primitive days,—of the formation of hills and seas, and of the creation of the two ruling lights as the result of the clearing up of the atmosphere. He considers the account of the creation in Genesis as adapted to the judgment of the vulgar. "Had Moses," he says, "described the processes of creation as distinctly as they were in themselves, he would have made the narrative tedious and confused amongst the vulgar, and become a philosopher more than a prophet." After referring to several "causes of meteors, such as the breaking out of vapours from below, before the earth was well hardened, the settling and shrinking of the whole globe after the upper regions or surface began to be hard," Newton closes his letter with an apology for being tedious, which, he says, "he has the more reason to do, as he has not set down any thing he has well considered, or will undertake to defend."—See the Letter in the Appendix to *Sir D. Brewster's Life of Newton*, vol. ii.

The primitive condition of the earth, and its preparation for man, was a subject of general speculation at the close of the seventeenth century. Leibnitz, like his great rival (Newton), attempted to explain the formation of the earth, and of the different substances which composed it; and he had the advantage of possessing some knowledge of geological phenomena: the earth he regarded as having been originally a burning mass, whose temperature gradually diminished till the vapours were condensed into a universal ocean, which covered the highest mountains, and gradually flowed into vacuities and subterranean cavities produced by the consolidation of the earth's crust. He regarded fossils as the real remains of plants and animals which had been buried in the strata; and, in speculating on the formation of mineral substances, he speaks of crystals as the geometry of inanimate nature.—*Brewster's Life of Newton*, vol. ii. p. 100, note. (See also "The Age of the Globe," in *Things not generally Known*, p. 13.)

"THE FATHER OF ENGLISH GEOLOGY."

In 1769 was born, the son of a yeoman of Oxfordshire, William Smith. When a boy he delighted to wander in the fields, collecting "pound-stones" (*Echinites*), "pundibs" (*Terebratulæ*), and other stony curiosities; and receiving little education beyond what he taught himself, he learned nothing of classics but the name. Grown to be a man, he became a land-surveyor and civil engineer, and was much engaged in constructing canals. While thus occupied, he observed that all the rocky masses forming the substrata of the country were gently inclined to the east and south-east,—that the red sandstones and marls above the *coal-measures* passed below the beds provincially termed lias-clay and limestone—that these again passed underneath the sands, yellow limestone, and clays that form the table-land of the Coteswold Hills; while they in turn plunged beneath the great escarpment of chalk that runs from the coast of Dorsetshire northward to the Yorkshire shores of the German Ocean. He further observed that each formation of clay, sand, or limestone, held to a very great extent its own peculiar suite of fossils. The "snake-stones" (*Ammonites*) of the lias were different in form and ornament from those of the inferior oolite; and the shells of the latter, again, differed from those of the Oxford clay, Cornbrash, and Kimmeridge clay. Pondering much on these things, he came to the then unheard-of conclusion that each formation had been in its turn a sea-bottom, in the sediments of which lived and died marine animals now extinct, many specially distinctive of their own epochs in time.

Here indeed was a discovery,—made, too, by a man utterly unknown to the scientific world, and having no pretension to scientific lore. "Strata Smith's" find was unheeded for many a long year; but at length the first geologists of the day learned from the land-surveyor that superposition of strata is inseparably connected with the succession of life in time. Hooke's grand vision was at length realised, and it was indeed possible "to build up a terrestrial chronology from rotten shells" imbedded in the rocks. Meanwhile he had constructed the first geological map of England, which has served as a basis for geological maps of all other parts of the world. William Smith was now presented by the Geological Society with the Wollaston Medal, and hailed as "the Father of English Geology."

He died in 1840. Till the manner as well as the fact of the first appearance of successive forms of life shall be solved, it is not easy to surmise how any discovery can be made in geology equal in value to that which we owe to the genius of William Smith.—*Saturday Review*, No. 140.

DR. BUCKLAND'S GEOLOGICAL LABOURS.

Sir Henry De la Beche, in his Anniversary Address to the Geological Society in 1848, on presenting the Wollaston Medal to Dr. Buckland, felicitously observed :

It may not be generally known that, while yet a child, at your native town, Axminster in Devonshire, ammonites, obtained by your father from the lime quarries in the neighbourhood, were presented to your attention. As a scholar at Winchester, the chalk, with its flints, was brought under your observation, and there it was that your collections in natural history first began. Removed to Oxford, as a scholar of Corpus Christi College, the future teacher of geology in that University was fortunate in meeting with congenial tastes in our colleague Mr. W. J. Broderip, then a student at Oriel College. It was during your walks together to Shotover Hill, when his knowledge of conchology was so valuable to you, enabling you to distinguish the shells of the Oxford oolite, that you laid the foundation for those field-lectures, forming part of your course of geology at Oxford, which no one is likely to forget who has been so fortunate at any time as to have attended them. The fruits of your walks with Mr. Broderip formed the nucleus of that great collection, more especially remarkable for tho organic remains it contains, which, after the labours of forty years, you have presented to the Geological Museum at Oxford, in grave recollection of the aid which the endowments of that University, and the leisure of its vacations, had afforded you for extensive travelling during a residence at Oxford of nearly forty-five years.

DISCOVERIES OF M. AGASSIZ.*

This great paleontologist, in the course of his ichthyological researches, was led to perceive that the arrangement by Cuvier according to organs did not fulfil its purpose with regard to fossil fishes, because in the lapse of ages the characteristics of their structures were destroyed. He therefore adopted the only other remaining plan, and studied the tissues, which, being less complex than the organs, are oftener found intact. The result was the very remarkable discovery, that the tegumentary membrane of fishes is so intimately connected with their organisation, that if the whole of the fish has perished except this membrane, it is practicable, by noting its characteristics, to reconstruct the animal in its most essential parts. Of the value of this principle of harmony, some idea may be formed from the circumstance, that on it Agassiz has based the whole of that celebrated classification of which he is the sole author, and by which fossil ichthyology has for the first time assumed a precise and definite shape. How essential its study is to the geologist appears from the remark of Sir Roderick Murchison, that "fossil fishes have every where proved the most exact chronometer of the age of rocks."

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* Longfellow has written some pleasing lines on "The Fiftieth Birthday of M. Agassiz. May 28, 1857," appended to "The Courtship of Miles Standish," 1858.

SUCCESSION OF LIFE IN TIME.

In the Museum of Economic Geology, in Jermyn Street, may be seen ores, metals, rocks, and whole suites of fossils stratigraphically arranged in such a manner that, with an observant eye for form, all may easily understand the more obvious scientific meanings of the Succession of Life in Time, and its bearing on geological economies. It is perhaps scarcely an exaggeration to say, that the greater number of so-called educated persons are still ignorant of the meaning of this great doctrine. They would be ashamed not to know that there are many suns and material worlds besides our own; but the science, equally grand and comprehensible, that aims at the discovery of the laws that regulated the creation, extension, decadence, and utter extinction of many successive species, genera, and whole orders of life, is ignored, or, if intruded on the attention, is looked on as an uncertain and dangerous dream,—and this in a country which was almost the nursery of geology, and which for half a century has boasted the first Geological Society in the world.—*Saturday Review*, No. 140.

PRIMITIVE DIVERSITY AND NUMBERS OF ANIMALS IN GEOLOGICAL TIMES.

Professor Agassiz considers that the very fact of certain stratified rocks, even among the oldest formations, being almost entirely made up of fragments of organised beings, should long ago have satisfied the most sceptical that both *animal and vegetable life were as active and profusely scattered upon the whole globe at all times, and during all geological periods, as they are now.* No coral reef in the Pacific contains a larger amount of organic *débris* than some of the limestone deposits of the tertiary, of the cretaceous, or of the oolitic, nay even of the paleozoic period; and the whole vegetable carpet covering the present surface of the globe, even if we were to consider only the luxuriant vegetation of the tropics, leaving entirely out of consideration the entire expanse of the ocean, as well as those tracts of land where, under less favourable circumstances, the growth of plants is more reduced,—would not form one single seam of workable coal to be compared to the many thick beds contained in the rocks of the carboniferous period alone.

ENGLAND IN THE EOCENE PERIOD.

Eocene is Sir Charles Lyell's term for the lowest group of the Tertiary system in which the dawn of recent life appears; and any one who wishes to realise what was the aspect presented by this country during the Eocene period, need only go to Sheerness. If, leaving that place behind him, he walks down the Thames, keeping close to the edge of the water, he will find whole bushels of pyritised pieces of twigs and fruits. These fruits and twigs belong to plants nearly allied to the screw-pine and custard-apple, and to various species of palms and spice-trees which now flourish in the Eastern Archipelago. At the time they were washed down from some neighbouring land, not only crocodilian reptiles, but sharks and innumerable turtles, inhabited a sea or estuary which now forms part of the London district; and huge boa-constrictors glided amongst the trees which fringed the adjoining shores.

Countless as are the ages which intervened between the Eocene period and the time when the little jawbones of Stonesfield were washed down to the place where they were to await the day when science should bring them again to light, not one mammalian genus which now lives upon our plane has been discovered amongst Eocene strata. We have existing families, but nothing more.—*Professor Owen.*

FOOD OF THE IGUANODON.

Dr. Mantell, from the examination of the anterior part of the right side of the lower jaw of an Iguanodon discovered in a quarry in Tilgate Forest, Sussex, has detected an extraordinary deviation from all known types of reptilian organisation, and which could not have been predicated; namely, that this colossal reptile, which equalled in bulk the gigantic Edentata of South America, and like them was destined to obtain support rom comminuted vegetable substances, was also furnished with a arge prehensile tongue and fleshy lips, to serve as instruments or seizing and cropping the foliage and branches of trees; while the arrangement of the teeth as in the ruminants, and heir internal structure, which resembles that of the molars of he sloth tribe in the vascularity of the dentine, indicate adap-ations for the same purpose.

Among the physiological phenomena revealed by paleonto-ogy, there is not a more remarkable one than this modification f the type of organisation peculiar to the class of reptiles to eet the conditions required by the economy of a lizard placed nder similar physical relations; and destined to effect the ame general purpose in the scheme of nature as the colossal

Edentata of former ages and the large herbivorous mammalia of our own times.

THE PTERODACTYL—THE FLYING DRAGON.

The Tilgate beds of the Wealden series, just mentioned, have yielded numerous fragments of the most remarkable reptilian fossils yet discovered, and whose wonderful forms denote them to have thronged the shallow seas and bays and lagoons of the period. In the grounds of the Crystal Palace at Sydenham the reader will find restorations of these animals sufficiently perfect to illustrate this reptilian epoch. They include the *iguanodon*, an herbivorous lizard exceeding in size the largest elephant, and accompanied by the equally gigantic and carnivorous *megalosaurus* (great saurian), and by the two yet more curious reptiles, the *pylæosaurus* (forest, or weald, saurian) and the pterodactyl (from *pteron*, 'wing,' and *dactylus*, 'a finger'), an enormous bat-like creature, now running upon the ground like a bird; its elevated body and long neck not covered with feathers, but with skin, naked, or resplendent with glittering scales; its head like that of a lizard or crocodile, and of a size almost preposterous compared with that of the body, with its long fore extremities stretched out, and connected by a membrane with the body and hind legs.

Suddenly this mailed creature rose in the air, and realised or even surpassed in strangeness *the flying dragon of fable:* its fore-arms and its elongated wing-finger furnished with claws; hand and fingers extended, and the interspace filled up by a tough membrane; and its head and neck stretched out like that of the heron in its flight. When stationary, its wings were probably folded back like those of a bird; though perhaps, by the claws attached to its fingers, it might suspend itself from the branches of trees.

MAMMALIA IN SECONDARY ROCKS.

It was supposed till very lately that few if any Mammalia were to be found below the Tertiary rocks, *i.e.* those above the chalk; and this supposed fact was very comfortable to those who support the doctrine of "progressive development," and hold, with the notorious *Vestiges of Creation*, that a fish by mere length of time became a reptile, a lemur an ape, and finally an ape a man. But here, as in a hundred other cases, facts, when duly investigated, are against their theory. A mammal jaw had been already discovered by Mr. Brodie on the shore at the back of Swanage Point, in Dorsetshire, when Mr. Beckles, F.G.S., traced the vein from which this jaw had been procured, and found it to be a stratum about five inches thick, at the base of the Middle Purbeck beds; and after removing many thousand tons of rock, and laying bare an area of nearly 7000 square feet (the largest cutting ever made for purely scientific purposes), he found reptiles (tortoises and lizards) in hundreds; but the most important discovery was that of the jaws of at least fourteen different species of mammalia. Some of these were herbivorous, some carnivorous, connected with our modern shrews, moles, hedgehogs, &c.; but all of them perfectly-developed and highly-organised quadrupeds. Ten years ago, no remains of quadrupeds were believed to exist in the Secondary strata. "Even in 1854," says Sir Charles Lyell (in a supplement to the fifth edition of his *Manual of Elementary Geology*), "only six species of mammals from rocks older than the Tertiary were known in the whole world." We now possess evidence of the existence of fourteen species, belonging to eight or nine genera, from the fresh-water strata of the Middle Purbeck Oolite. It would be rash now to fix a limit in past time to the existence of quadrupeds.—*The Rev. C. Kingsley.*

FOSSIL HUMAN BONES.

In the paleontological collection in the British Museum is preserved a considerable portion of a human skeleton imbedded in a slab of rock, brought from Guadaloupe, and often referred to in opposition to the statement that hitherto *no fossil human bones have been found.* The presence of these bones, however, has been explained by the circumstance of a battle and the massacre of a tribe of Galtibis by the Caribs, which took place near the spot in which the bones were found about 130 years ago; for as the bodies of the slain were interred on the seashore, their skeletons may have been subsequently covered by sand-drift, which has since consolidated into limestone.

It will be seen by reference to the *Philosophical Transactions*, that on the reading of the paper upon this discovery to the Royal Society, in 1814, Sir Joseph Banks, the president, considered the "fossil" to be of very modern formation, and that probably, from the contiguity of a volcano, the temperature of the water may have been raised at some time, and dissolving carbonate of lime readily, may have deposited about the skeleton in a comparatively short period hard and solid stone. Every person may be convinced of the rapidity of the formation and of the hardness of such stone by inspecting the inside of tea-kettles in which hard water is boiled.

Descriptions of petrifactions of human bodies appear to refer to the conversion of bodies into adipocere, and not into stone. All the supposed cases of petrifaction are probably of this nature. The change occurs only when the coffin becomes filled with water. The body, converted into adipocero, floats on the water. The supposed cases of changes of position in the grave, bursting open the coffin-lids, turning over, crossing of limbs, &c., formerly attributed to the coming to life of persons buried who were not dead, is now ascertained to be due to the same cause. The chemical change into adipocere, and the evolution of gases, produce these movements of dead bodies.—*Mr. Trail Green.*

THE MOST ANCIENT FISHES.

Among the important results of Sir Roderick Murchison's establishment of the Silurian system is the following:

That as the Lower Silurian group, often of vast dimensions, has never afforded the smallest vestige of a Fish, though it abounds in numerous species of the *marine* classes,—corals, *crinoidea, mollusca,* and *crustacea;* and as in Scandinavia and Russia, where it is based on rocks void of fossils, its lowest stratum contains *fucoids* only,—Sir R. Murchison has, after fifteen years of laborious research steadily directed to this point, arrived at the conclusion, that a very long period elapsed after life was breathed into the waters before the lowest order of vertebrata was created; the earliest fishes being those of the Upper Silurian rocks, which he was the first to discover, and which he described "as the most ancient beings of their class which have yet been brought to light." Though the Lower Silurian rocks of various parts of the world have since been ransacked by multitudes of prying geologists, who have exhumed from them myriads of marine fossils, not a single ichthyolite has been found in any stratum of higher antiquity than the Upper Silurian group of Murchison.

The most remarkable of all fossil fishes yet discovered have been found in the Old Red Sandstone cliffs at Dorpat, where the remains are so gigantic (one bone measuring *two feet nine inches* in length) that they were at first supposed to belong to saurians.

Sir Roderick's examination of Russia has, in short, proved that *the ichthyolites and mollusks which, in Western Europe, are separately peculiar to smaller detached basins, were here (in the British Isles) cohabitants of many parts of the same great sea.*

EXTINCT CARNIVOROUS ANIMALS OF BRITAIN.

Professor Owen has thus forcibly illustrated the Carnivorous Animals which preyed upon and restrained the undue multiplication of the vegetable feeders. First we have the bear family, which is now represented in this country only by the badger. We were once blest, however, with many bears. One species seems to have been identical with the existing brown bear of the European continent. Far larger and more formidable was the gigantic cave-bear (*Ursus spelæus*), which surpassed in size his grisly brother of North America. The skull of the cave-bear differs very much in shape from that of its small brown relative just alluded to; the forehead, in particular, is much higher,—to be accounted for by an arrangement of air-cells similar to those which we have already remarked in the elephant.

The cave-bear has left its remains in vast abundance in Germany. In our own caves, the bones of hyænas are found in greater quantities. The marks which the teeth of the hyæna make upon the bones which it gnaws are quite unmistakable. Our English hyænas had the most undiscriminating appetite, preying upon every creature, their own species amongst others. Wolves, not distinguishable from those which now exist in France and Germany, seem to have kept company with the hyænas; and the *Felis spelæa*, a sort of lion, but larger than any which now exists, ruled over all weaker brutes. Here, says Professor Owen, we have the original British Lion. A species of *Machairodus* has left its remains at Kent's Hole, near Torquay. In England we had also the beaver, which still lingers on the Danube and the Rhone, and a larger species, which has been called Trogontherium (gnawing beast), and a gigantic mole.

THE GREAT CAVE TIGER OR LION OF BRITAIN.

Remains of this remarkable animal of the drift or gravel period of this country have been found at Brentford and elsewhere near London. Speaking of this animal, Professor Owen observes, that "it is commonly supposed that the Lion, the Tiger, and the Jaguar are animals peculiarly adapted to a tropical climate. The genus Felis (to which these animals belong) is, however, represented by specimens in high northern latitudes, and in all the intermediate countries to the equator." The chief condition necessary for the presence of such animals is an abundance of the vegetable-feeding animals. It is thus that the Indian tiger has been known to follow the herds of antelope and deer in the lofty mountains of the Himalaya to the verge of perpetual snow, and far into Siberia. "It need not, therefore," continues Professor Owen, "excite surprise that indications should have been discovered in the fossil relics of the ancient mammalian population of Europe of a large feline animal, the contemporary of the mammoth, of the tichorrhine rhinoceros, of the great gigantic cave-bear and hyæna, and the slayer of the oxen, deer, and equine quadrupeds that so abounded during the same epoch." The dimensions of this extinct animal equal those of the largest African lion or Bengal tiger; and some bones have been found which seem to imply that it had even more powerful limbs and larger paws.

THE MAMMOTHS OF THE BRITISH ISLES.

Dr. Buckland has shown that for long ages many species of carnivorous animals now extinct inhabited the caves of the British islands. In low tracts of Yorkshire, where tranquil lacustrine (lake-like) deposits have occurred, bones (even those of the lion) have been found so perfectly unbroken and unworn, in fine gravel (as at Market Weighton), that few persons would be disposed to deny that such feline and other animals once roamed over the British isles, as well as other European countries. Why, then, is it improbable that large elephants, with a peculiarly thick integument, a close coating of wool, and much long shaggy hair, should have been the occupants of wide tracts of Northern Europe and Asia? This coating, Dr. Fleming has well remarked, was probably as impenetrable to rain and cold as that of the monster ox of the polar circle. Such is the opinion of Sir Roderick Murchison, who thus accounts for the disappearance of the mammoths from Britain:

> When we turn from the great Siberian continent, which, anterior to its elevation, was the chief abode of the mammoths, and look to the other parts of Europe, where their remains also occur, how remarkable is it that we find the number of these creatures to be justly proportionate to the magnitude of the ancient masses of land which the labours of geologists have defined! Take the British isles, for example, and let all their low, recently elevated districts be submerged; let, in short, England be viewed as the comparatively small island she was when the ancient estuary of the Thames, including the plains of Hyde Park, Chelsea, Hounslow, and Uxbridge, were under the water; when the Severn extended far into the heart of the kingdom, and large eastern tracts of the island were submerged,—and there will then remain but moderately-sized feeding-grounds for the great quadrupeds whose bones are found in the gravel of the adjacent rivers and estuaries.

This limited area of subsistence could necessarily only keep up a small stock of such animals; and, just as we might expect, the remains of British mammoths occur in very small numbers indeed, when compared with those of the great charnel-houses of Siberia, into which their bones had been carried down through countless ages from the largest mass of surface which geological inquiries have yet shown to have been *dry land* during that epoch.

The remains of the mammoth, says Professor Owen, have been found in all, or almost all, the counties of England. Off the coast of Norfolk they are met with in vast abundance. The fishermen who go to catch turbot between the mouth of the Thames and the Dutch coast constantly get their nets entangled in the tusks of the mammoth. A collection of tusks and other remains, obtained in this way, is to be seen at Ramsgate. In North America, this gigantic extinct elephant must have been very common; and a large portion of the ivory which supplies the markets of Europe is derived from the vast mammoth graveyards of Siberia.

The mammoth ranged at least as far north as 60°. There is no doubt that, at the present day, many specimens of the musk-ox are annually becoming imbedded in the mud and ice of the North-American rivers.

It is curious to observe, that the mammoth teeth which are met with in caves generally belonged to young mammoths, who probably resorted thither for shelter before increasing age and strength emboldened them to wander far afield.

THE RHINOCEROS AND HIPPOPOTAMUS OF ENGLAND.

The mammoth was not the only giant that inhabited England in the Pliocene or Upper Tertiary period. We had also here the *Rhinoceros tichorrhinus*, or "strongly walled about the nose," remains of which have been discovered in enormous quantities in the brickfields about London. Pallas describes an entire specimen of this creature, which was found near Yakutsk, the coldest town on the globe. Another rhinoceros, *leptorrhinus* (fine nose), dwelt with the elephant of Southern Europe. In Siberia has been discovered the Elaimotherium, forming a link between the rhinoceros and the horse.

In the days of the mammoth, we had also in England a Hippopotamus, rather larger than the species which now inhabits the Nile. Of our British hippopotamus some remains were dug up by the workmen in preparing the foundations of the New Junior United Service Club-house, in Regent-street.

THE ELEPHANT AND TORTOISE.

The idea of an Elephant standing on the back of a Tortoise was often laughed at as an absurdity, until Captain Cautley and Dr. Falconer at length discovered in the hills of Asia the remains of a tortoise in a fossil state of such a size that an elephant could easily have performed the above feat.

COEXISTENCE OF MAN AND THE MASTODON.

Dr. C. F. Winslow has communicated to the Boston Society of Natural History the discovery of the fragment of a human cranium 180 feet below the surface of the Table Mountain, California. Now the mastodon's bones being found in the same deposits, points very clearly to the probability of the appearance of the human race on the western portions of North America at least before the extinction of those huge creatures. Fragments of mastodon and *Elephas primigenius* have been taken ten and twenty feet below the surface in the above locality; where this discovery of human and mastodon remains gives strength to the possible truth of an old Indian tradition, —the contemporary existence of the mammoth and aboriginals in this region of the globe.

HABITS OF THE MEGATHERIUM.

Much uncertainty has been felt about the habits of the Megatherium, or Great Beast. It has been asked whether it burrowed or climbed, or what it did; and difficulties have presented themselves on all sides of the question. Some have thought that it lived in trees as much larger than those which now exist as the Megatherium itself is larger than the common sloth.* This, however, is now known to be a mistake. It did not climb trees—it pulled them down; and in order to do this the hinder parts of its skeleton were made enormously strong, and its prehensile fore-legs formed so as to give it a tremendous power over any thing which it grasped. Dr. Buckland suggested that animals which got their living in this way had a very fair chance of having their heads broken. While Professor Owen was still pondering over this difficulty, the skull of a cognate animal, the Mylodon, came into his hands. Great was his delight when he found that the mylodon not only had his head broken, but broken in two different places, at two different times; and moreover so broken that the injury could only have been inflicted by some such agent as a fallen tree. The creature had recovered from the first blow, but had evidently died of the second. This tribe had, as it turns out, two skulls, an outer and an inner one—given them, as it would appear, expressly with a view to the very dangerous method in which they were intended to obtain their necessary food.

The dentition of the megatherium is curious. The elephant gets teeth as he wants them. Nature provided for the comfort of the megatherium in another way. It did not get new teeth, but the old ones went on for ever growing as long as the animal lived; so that as fast as one grinding surface became useless, another supplied its place.

THE DINOTHERIUM, OR TERRIBLE BEAST.

The family of herbivorous Cetaceans are connected with the Pachydermata of the land by one of the most wonderful of all the extinct creatures with which geologists have made us acquainted. This is the *Dinotherium*, or Terrible Beast. The remains of this animal were found in Miocene sands at Eppelsheim, about forty miles from Darmstadt. It must have been larger than the largest extinct or living elephant. The most remarkable peculiarity of its structure is the enormous tusks, curving downwards and terminating its lower jaw. It appears to have lived in the water, where the immense weight of these formidable appendages would not be so inconvenient as on land What these tusks were used for is a mystery; but perhaps they acted as pickaxes in digging up trees and shrubs, or as harrows in raking the bottom of the water. Dr. Buckland used to suggest that they were perhaps employed as anchors, by means of which the monster might fasten itself to the bank of a stream and enjoy a comfortable nap. The extreme length of the *Dinotherium* was about eighteen feet. Professor Kemp, in his restoration of the animal, has given it a trunk like that of the elephant, but not so long, and the general form of the tapir. —*Professor Owen.*

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* The *sloth* only deserves its name when it is obliged to attempt to proceed along the ground; when it has any thing which it can lay hold of it is agile enough.

THE GLYPTODON.

There are few creatures which we should less have expected to find represented in fossil history by a race of gigantic brethren than the armadillo. The creature is so small, not only in size but in all its works and ways, that we with difficulty associate it with the idea of magnitude. Yet Sir Woodbine Parish has discovered evidences of enormous animals of this family having once dwelt in South America. The huge loricated (plated over) creature whose relics were first sent has received the name of Glyptodon, from its sculptured teeth. Unlike the small armadillos, it was unable to roll itself up into a ball; though an enormous carnivore which lived in those days must have made it sometimes wish it had the power to do so. When attacked, it must have crouched down, and endeavoured to make its huge shell as good a defence as possible.—*Professor Owen.*

INMATES OF AN AUSTRALIAN CAVERN.

From the fossil-bone caverns in Wellington Valley, in 1830, were sent to Professor Owen several bones which belonged, as it turned out, to gigantic kangaroos, immensely larger than any existing species; to a kind of wombat, to formidable dasyures, and several other genera. It also appeared that the bones, which were those of herbivores, had evidently belonged to young animals, while those of the carnivores were full-sized; a fact which points to the relations between the two families having been any thing but agreeable to the herbivores.

THE POUCH-LION OF AUSTRALIA.

The *Thylacoleo* (Pouch-Lion) was a gigantic marsupial carnivore, whose character and affinities Professor Owen has, with exquisite scientific tact, made out from very small indications. This monster, which had kangaroos with heads three feet long to feed on, must have been one of the most extraordinary animals of the antique world.

THE CONEY OF SCRIPTURE.

Paleontologists have pointed out the curious fact that the

Hyrax, called 'coney' in our authorised version of the Bible, is really only a diminutive and hornless rhinoceros. Remains have been found at Eppelsheim which indicate an animal more like a gigantic Hyrax than any of the existing rhinoceroses. To this the name of *Acerotherium* (Hornless Beast) has been given.

A THREE-HOOFED HORSE.

Professor Owen describes the *Hipparion*, or Three-hoofed Horse, as the first representative of a family so useful to mankind. This animal, in addition to its true hoof, appears to have had two additional elementary hoofs, analogous to those which we see in the ox. The object of these no doubt was to enable the Hipparion to extricate his foot with greater ease than he otherwise could when it sank through the swampy ground on which he lived.

TWO MONSTER CARNIVORES OF FRANCE.

A huge carnivorous creature has been found in Miocene strata in France, in which country it preyed upon the gazelle and antelope. It must have been as large as a grisly bear, but in general appearance and teeth more like a gigantic dog. Hence the name of *Amphicyon* (Doubtful Dog) has been assigned to it. This animal must have derived part of its support from vegetables. Not so the coeval monster which has been called *Machairodus* (Sabre-tooth). It must have been somewhat akin to the tiger, and is by far the most formidable animal which we have met with in our ascending progress through the extinct mammalia.—*Professor Owen.*

GEOLOGY OF THE SHEEP.

No unequivocal fossil remains of the sheep have yet been found in the bone-caves, the drift, or the more tranquil stratified newer Pliocene deposits, so associated with the fossil bones of oxen, wild-boars, wolves, foxes, otters, &c., as to indicate the coevality of the sheep with those species, or in such an altered state as to indicate them to have been of equal antiquity. Professor Owen had his attention particularly directed to this point in collecting evidence for a history of British Fossil Mammalia. No fossil core-horns of the sheep have yet been any where discovered; and so far as this negative evidence goes, we may infer that the sheep is not geologically more ancient than man; that it is not a native of Europe, but has been introduced by the tribes who carried hither the germs of civilisation in their migrations westward from Asia.

THE TRILOBITE.

Among the earliest races we have those remarkable forms.

the Trilobites, inhabiting the ancient ocean. These crustacea remotely resemble the common wood-louse, and like that animal they had the power of rolling themselves into a ball when attacked by an enemy. The eye of the trilobite is a most remarkable organ; and in that of one species, *Phacops caudatus*, not less than 250 lenses have been discovered. This remarkable optical instrument indicates that these creatures lived under similar conditions to those which surround the crustacea of the present day.—*Hunt's Poetry of Science.*

PROFITABLE SCIENCE.

In that strip of reddish colour which runs along the cliffs of Suffolk, and is called the Redcrag, immense quantities of cetacean remains have been found. Four different kinds of whales, little inferior in size to the whalebone whale, have left their bones in this vast charnel-house. In 1840, a singularly perplexing fossil was brought to Professor Owen from this Redcrag. No one could say what it was. He determined it to be the tooth of a cetacean, a unique specimen. Now the remains of cetaceans in the Suffolk crag have been discovered in such enormous quantities, that many thousands a-year are made by converting them into manure.

EXTINCT GIGANTIC BIRDS OF NEW ZEALAND.

In the islands of New Zealand have been found the bones of large extinct wingless Birds, belonging to the Post Tertiary or Recent system, which have been deposited by the action of rivers. The bird is named *Moa* by the natives, and *Dinornis* by naturalists: some of the bones have been found in two caves in the North Island, and have been sold by the natives at an extraordinary price. The caves occur in limestone rocks, and the bones are found beneath earth and a soft deposit of carbonate of lime. The largest of the birds is stated to have stood thirteen or fourteen feet, or twice the height of the ostrich; and its egg large enough to fill the hat of a man as a cup. Several statements have appeared of these birds being still in existence, but there is every reason to believe the Moa to be altogether extinct.

An extensive collection of remains of these great wingless birds has been collected in New Zealand by Mr. Walter Mantell, and deposited in the British Museum. Among these bones Professor Owen has discovered a species which he regards as the most remarkable of the feathered class for its prodigious strength and massive proportions, and which he names *Dinornis elephantopus*, or elephant-footed, of which the Professor has been able to construct an entire lower limb: the length of the metatarsal bone is 9¼ inches, the breadth of the lower end being 5½ inches. The extraordinary proportions of the metatarsus of this wingless bird will, however, be still better understood by comparison with the same bone in the ostrich, in which the metatarsus is 19 inches in length, the breadth of its lower end being only 2½ inches. From the materials accumulated by Mr. Mantell, the entire skeleton of the *Dinornis elephantopus* has been reconstructed; and now forms a worthy companion of the Megatherium and Mastodon in the gallery of fossil remains in the British Museum. This species of *Dinornis* appears to have been restricted to the Middle Island of New Zealand.*

Another specimen of the remains of the *Dinornis* is preserved in the Museum of the Royal College of Surgeons, in Lincoln's-Inn Fields; and the means by which the college obtained this valuable acquisition is thus graphically narrated by Mr. Samuel Warren, F.R.S.:

> In the year 1839, Professor Owen was sitting alone in his study, when a shabbily-dressed man made his appearance, announcing that he had got a great curiosity, which he had brought from New Zealand, and wished to dispose of to him. It had the appearance of an old marrow-bone, about six inches in length, and rather more than two inches in thickness, *with both extremities broken off;* and Professor Owen considered that, to whatever animal it might have belonged, the fragment must have lain in the earth for centuries. At first he considered this same marrow-bone to have belonged to an ox, at all events to a quadruped; for the wall or rim of the bone was six times as thick as the bone of any bird, even of the ostrich. He compared it with the bones in the skeleton of an ox, a horse, a camel, a tapir, and every quadruped apparently possessing a bone of that size and configuration; but it corresponded with none. On this he very narrowly examined the surface of the bony rim, and at length became satisfied that this fragment must have belonged to *a bird!*—to one at least *as* large as an ostrich, but of a totally different species; and consequently one never before heard of, as an ostrich was by far the biggest bird known.
>
> From the difference in the *strength* of the bone, the ostrich being unable to fly, so must have been unable this unknown bird; and so our anatomist came to the conclusion that this old shapeless bone indicated the former existence in New Zealand of some huge bird, at least as great as an ostrich, but of a far heavier and more sluggish kind. Professor Owen was confident of the validity of his conclusions, but would communicate that confidence to no one else; and notwithstanding attempts to dissuade him from committing his views to the public, he printed his deductions in the *Transactions of the Zoological Society for* 1839, where fortunately they remain on record as conclusive evidence of the fact of his having then made this guess, so to speak, in the dark. He caused the bone, however, to be engraved; and having sent a hun-

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* Dr. A. Thomson has communicated to *Jameson's Journal*, No. 112, a Description of the Caves in the North Island, with some general observations on this genus of birds. He concludes them to have been indolent, dull, and stupid; to have lived chiefly on vegetable food in mountain fastnesses and secluded caverns.

In the picture-gallery at Drayton Manor, the seat of Sir Robert Peel, hangs a portrait of Professor Owen, and in his hand is depicted the tibia of a Moa.

dred copies of the engraving to New Zealand, in the hope of their being distributed and leading to interesting results, he patiently waited for three years,—viz. till the year 1842,—when he received intelligence from Dr. Buckland, at Oxford, that a great box, just arrived from New Zealand, consigned to himself, was on its way, unopened, to Professor Owen, who found it filled with bones, palpably of a bird, one of which bones was three feet in length, and much more than double the size of any bone in the ostrich!

And out of the contents of this box the Professor was positively enabled to articulate almost the entire skeleton of a huge wingless bird between TEN and ELEVEN feet in height, its bony structure in strict conformity with the fragment in question; and that skeleton may at any time be seen at the Museum of the College of Surgeons, towering over, and nearly twice the height of, the skeleton of an ostrich; and at its feet lying the old bone from which alone consummate anatomical science had deduced such an astounding reality,—the existence of an enormous extinct creature of the bird kind, in an island where previously no bird had been known to exist larger than a pheasant or a common fowl!—*Lecture on the Moral and Intellectual Development of the present Age.**

"THE MAESTRICHT SAURIAN FOSSIL" A FRAUD.

In 1795, there was stated to have been discovered in the stone quarries adjoining Maestricht the remains of the gigantic *Mosœsaurus* (Saurian of the Meuse), an aquatic reptile about twenty-five feet long, holding an intermediate place between the Monitors and Iguanas. It appears to have had webbed feet, and a tail of such construction as to have served for a powerful oar, and enabled the animal to stem the waves of the ocean, of which Cuvier supposed it to have been an inhabitant. It is thus referred to by Dr. Mantell, in his *Medals of Creation*: "A specimen, with the jaws and bones of the palate, now in the Museum at Paris, has long been celebrated; and is still the most precious relic of this extinct reptile hitherto discovered." An admirable cast of this specimen is preserved in the British Museum, in a case near the bones of the Iguanodon. This is, however, useless, as Cuvier is proved to have been imposed upon in the matter.

M. Schlegel has reported to the French Academy of Sciences, that he has ascertained beyond all doubt that the famous fossil saurian of the quarries of Maestricht, described as a wonderful curiosity by Cuvier, is nothing more than an impudent fraud. Some bold impostor, it seems, in order to make money, placed a quantity of bones in the quarries in such a way as to give them the appearance of having been recently dug up, and then passed them off as specimens of antediluvian creation. Being successful in this, he went the length of arranging a number of bones so as to represent an entire skeleton; and had thus deceived the learned Cuvier. In extenuation of Cuvier's credulity, it is stated that the bones were so skilfully coloured as to make them look of immense antiquity, and he was not allowed to touch them lest they should crumble to pieces. But when M. Schlegel subjected them to rude handling, he found that they were comparatively modern, and that they were placed one by the other without that profound knowledge of anatomy which was to have been expected from the man bold enough to execute such an audacious fraud.

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* According to the law of correlation, so much insisted on by Cuvier, a superior character implies the existence of its inferiors, and that too in definite proportions and constant connections; so that we need only the assurance of one character, to be able to reconstruct the whole animal. The triumph of this system is seen in the reconstruction of extinct animals, as in the above case of the Dinornis, accomplished by Professor Owen.

"THE OLDEST PIECE OF WOOD UPON EARTH."

The most remarkable vegetable relic which the Lower Old Red Sandstone has given us is a small fragment of a coniferous tree of the Araucarian family, which formed one of the chief ornaments of the late Hugh Miller's museum, and to which he used to point as the oldest piece of wood upon earth. He found it in one of the ichthyolite beds of Cromarty, and thus refers to it in his *Testimony of the Rocks:*

> On what perished land of the early paleozoic ages did this venerably antique tree cast root and flourish, when the extinct genera Pterichthys and Coccoeteus were enjoying life by millions in the surrounding seas, long ere the flora or fauna of the coal measures had begun to be?
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> The same nodule which enclosed this lignite contained part of another fossil, the well-marked scales of *Diplacanthus striatus*, an ichthyolite restricted to the Lower Old Red Sandstone exclusively. If there be any value in paleontological evidence, this Cromarty lignite must have been deposited in a sea inhabited by the Coccoeteus and Diplacanthus. It is demonstrable that, while yet in a recent state, a Diplacanthus lay down and died beside it; and the evidence in the case is unequivocally this, that in the oldest portion of the oldest terrestrial flora yet known there occurs the fragment of a tree quite as high in the scale as the stately Norfolk-Island pine or the noble cedar of Lebanon.

NO FOSSIL ROSE.

Professor Agassiz, in a lecture upon the trees of America, states a remarkable fact in regard to the family of the rose,—which includes among its varieties not only many of the most beautiful flowers, but also the richest fruits, as the apple, pear, peach, plum, apricot, cherry, strawberry, raspberry, &c.,—namely, that *no fossil plants belonging to this family have ever been discovered by geologists!* This M. Agassiz regards as conclusive evidence that the introduction of this family of plants upon the earth was coeval with, or subsequent to, the creation of man, to whose comfort and happiness they seem especially designed by a wise Providence to contribute.

CHANGES ON THE EARTH'S SURFACE.

In the Imperial Library at Paris is preserved a manuscript work by an Arabian writer, Mohammed Karurini, who flourished in the seventh century of the Hegira, or at the close of the thirteenth century of our era. Herein we find several curious remarks on aerolites and earthquakes, and the successive changes of position which the land and sea have undergone. Of the latter class is the following beautiful passage from the narrative of Khidz, an allegorical personage:

> I passed one day by a very ancient and wonderfully populous city, and asked one of its inhabitants how long it had been founded. "It is indeed a mighty city," replied he; "we know not how long it has existed, and our ancestors were on this subject as ignorant as ourselves." Five centuries afterwards, as I passed by the same place, I could not perceive the slightest vestige of the city. I demanded of a peasant who was gathering herbs upon its former site how long it had been destroyed. "In sooth, a strange question," replied he; "the ground here has never been different from what you now behold it." "Was there not of old," said I, "a splendid city here?" "Never," answered he, "so far as we have seen; and never did our fathers speak to us of any such." On my return there five hundred years afterwards, *I found the sea in the same place;* and on its shores were a party of fishermen, of whom I inquired how long the land had been covered by the waters. "Is this a question," say they, "for a man like you? This spot has always been what it is now." I again returned five hundred years afterwards; the sea had disappeared: I inquired of a man who stood alone upon the spot how long this change had taken place, and he gave me the same answer as I had received before. Lastly, on coming back again after an equal lapse of time, I found there a flourishing city, more populous and more rich in beautiful buildings than the city I had seen the first time; and when I would fain have informed myself concerning its origin, the inhabitants answered me, "Its rise is lost in remote antiquity: we are ignorant how long it has existed, and our fathers were on this subject as ignorant as ourselves."

This striking passage was quoted in the *Examiner*, in 1834. Surely in this fragment of antiquity we trace the "geological changes" of modern science.

GEOLOGICAL TIME.

Many ingenious calculations have been made to approximate the dates of certain geological events; but these, it must be confessed, are more amusing than instructive. For example, so many inches of silt are yearly laid down in the delta of the Mississippi—how many centuries will it have taken to accumulate a thickness of 30, 60, or 100 feet? Again, the ledges of Niagara are wasting at the rate of so many feet per century—how many years must the river have taken to cut its way back from Queenstown to the present Falls? Again, lavas and melted basalts cool, according to the size of the mass, at the rate of so many degrees in a given time—how many millions of years must have elapsed, supposing an original igneous condition of the earth, before its crust had attained a state of solidity? or further, before its surface had cooled down to the present mean temperature? For these and similar computations, the student will at once perceive we want the necessary uniformity of factor; and until we can bring elements of calculation as exact as those of astronomy to bear on geological chronology, it will be better to regard our "eras" and "epochs" and "systems" as so many terms, indefinite in their duration, but sufficient for the magnitude of the operations embraced within their limits.—*Advanced Textbook of Geology, by David Page, F.G.S.*

M. Rozet, in 1841, called attention to the fact, that the causes which have produced irregularities in the structure of the globe have not yet ceased to act, as is proved by earthquakes, volcanic eruptions, slow and continuous movements of the crust of the earth in certain regions, &c. We may, therefore, yet see repeated the great catastrophes which the surface of the earth has undergone anteriorly to the historical period.

At the meeting of the British Association in 1855, Mr. Hopkins excited much controversy by his startling speculation—that 9000 years ago the site on which London now stands was in the torrid zone; and that, according to perpetual changes in progress, the whole of England would in time arrive within the Arctic circle.

CURIOUS CAUSE OF CHANGE OF LEVEL.

Professor Hennessey, in 1857, found *the entire mass of rock and hill on which the Armagh Observatory is erected to be slightly, but to an astronomer quite perceptibly, tilted or canted, at one season to the east, at another to the west.* This he at first attributed to the varying power of the sun's radiation to heat and expand the rock throughout the year; but he subsequently had reason to attribute it rather to the infiltration of water to the parts where the clay-slate and limestone rocks met, the varying quantity of the water exerting a powerful hydrostatic energy by which the position of the rock is slightly varied.

Now Armagh and its observatory stand at the junction of the mountain limestone with the clay-slate, having, as it were, one leg on the former and the other on the latter; and both rocks probably reach downwards 1000 or 2000 feet. When rain falls, the one will absorb more water than the other; both will gain an increase of conductive power; but the one which has absorbed most water will have the greatest increase, and being thus the better conductor, will *draw a greater portion of heat from the hot nucleus below to the surface*—will become, in fact, temporarily hotter, and, as a consequence, *expand more than the other.* In a word, *both rocks will expand at the wet season; but the best conductor, or most absorbent rock, will expand most, and seem to tilt the hill to one side; at the dry season it will* *subside most, and the hill will seem to be tilted in the opposite direction.*

The fact is curious, and not less so are the results deducible from it. First, hills are higher at one season than another; a fact we might have supposed, but never could have ascertained by measurement. Secondly, they are highest, not, as we should have supposed, at the hottest season, but at the wettest. Thirdly, it is from the *different rates* of expansion of different rocks that this has been discovered. Fourthly, it is by converse with the *heavens* that it has been made known to us. A variation of probably half a second, or less, in the right ascension of three or four stars, observed at different seasons, no doubt revealed the fact to the sagacious astronomer of Armagh, and even enabled him to divine its cause.

Professor Hennessey observes in connection with this phenomenon, that a very small change of ellipticity would suffice to lay bare or submerge extensive tracts of the globe. If, for example, the mean ellipticity of the ocean increased from $\frac{1}{300}$ to $\frac{1}{299}$, the level of tho sea would be raised at the equator by about 228 feet, while under the parallel of 52° it would be depressed by 196 feet. Shallow seas and banks in the latitudes of the British isles, and between them and the pole, would thus be converted into dry land, while low-lying plains and islands near tho equator would be submerged. If similar phenomena occurred during early periods of geological history, they would manifestly influenco the distribution of land and water during these periods; and with such a direction of the forces as that referred to, they would tend to increase the proportion of land in the polar and temperate regions of the earth, as compared with the equatorial regions during successive geological epochs. Such maps as those published by Sir Charles Lyell on the distribution of land and water in Europe during the Tertiary period, and those of M. Elie de Beaumont, contained in Beaudant's *Geology*, would, if sufficiently extended, assist in verifying or disproving these views.

THE OUTLINES OF CONTINENTS NOT FIXED.

Continents (says M. Agassiz) are only a patchwork formed by the emergence and subsidence of land. These processes are still going on in various parts of the globe. Where the shores of the continent are abrupt and high, the effect produced may be slight, as in Norway and Sweden, where a gradual elevation is going on without much alteration in their outlines. But if the continent of North America were to be depressed 1000 feet, nothing would remain of it except a few islands, and any elevation would add vast tracts to its shores.

The west of Asia, comprising Palestine and the country about Ararat and the Caspian Sea, is below the level of the ocean, and a rent in the mountain-chains by which it is surrounded would transform it into a vast gulf.

Meteorological Phenomena.

THE ATMOSPHERE.

A PHILOSOPHER of the East, with a richness of imagery truly oriental, describes the Atmosphere as "a spherical shell which surrounds our planet to a depth which is unknown to us, by reason of its growing tenuity, as it is released from the pressure of its own superincumbent mass. Its upper surface cannot be nearer to us than 50, and can scarcely be more remote than 500, miles. It surrounds us on all sides, yet we see it not; it presses on us with a load of fifteen pounds on every square inch of surface of our bodies, or from seventy to one hundred tons on us in all, yet we do not so much as feel its weight. Softer than the softest down, more impalpable than the finest gossamer, it leaves the cobweb undisturbed, and scarcely stirs the lightest flower that feeds on the dew it supplies; yet it bears the fleets of nations on its wings around the world, and crushes the most refractory substances with its weight. When in motion, its force is sufficient to level the most stately forests and stable buildings with the earth—to raise the waters of the ocean into ridges like mountains, and dash the strongest ships to pieces like toys. It warms and cools by turns the earth and the living creatures that inhabit it. It draws up vapours from the sea and land, retains them dissolved in itself or suspended in cisterns of clouds, and throws them down again as rain or dew when they are required. It bends the rays of the sun from their path to give us the twilight of evening and of dawn; it disperses and refracts their various tints to beautify the approach and the retreat of the orb of day. But for the atmosphere sunshine would burst on us and fail us at once, and at once remove us from midnight darkness to the blaze of noon. We should have no twilight to soften and beautify the landscape; no clouds to shade us from the searching heat; but the bald earth, as it revolved on its axis, would turn its tanned and weakened front to the full and unmitigated rays of the lord of day. It affords the gas which vivifies and warms our frames, and receives into itself that which has been polluted by use and is thrown off as noxious. It feeds the flames of life exactly as it does that of the fire—it is in both cases consumed and affords the food of consumption—in both cases it becomes combined with charcoal, which requires it for combustion and is removed by it when this is over."

UNIVERSALITY OF THE ATMOSPHERE.

It is only the girdling, encircling air that flows above and around all that makes the whole world kin. The carbonic acid with which to-day our breathing fills the air, to-morrow makes its way round the world. The date-trees that grow round the falls of the Nile will drink it in by their leaves; the cedars of Lebanon will take of it to add to their stature; the cocoanuts of Tahiti will grow rapidly upon it; and the palms and bananas of Japan will change it into flowers. The oxygen we are breathing was distilled for us some short time ago by the magnolias of the Susquehanna; the great trees that skirt the Orinoco and the Amazon, the giant rhododendrons of the Himalayas, contributed to it, and the roses and myrtles of Cashmere, the cinnamon-tree of Ceylon, and the forest, older than the Flood, buried deep in the heart of Africa, far behind the Mountains of the Moon. The rain we see descending was thawed for us out of the icebergs which have watched the polar star for ages; and the lotus-lilies have soaked up from the Nile, and exhaled as vapour, snows that rested on the summits of the Alps.—*North-British Review.*

THE HEIGHT OF THE ATMOSPHERE.

The differences existing between that which appertains to the air of heaven (the realms of universal space) and that which belongs to the strata of our terrestrial atmosphere are very striking. It is not possible, as well-attested facts prove, perfectly to explain the operations at work in the much-contested upper boundaries of our atmosphere. The extraordinary lightness of whole nights in the year 1831, during which small print might be read at midnight in the latitudes of Italy and the north of Germany, is a fact directly at variance with all we know according to the researches on the crepuscular theory and the height of the atmosphere. The phenomena of light depend upon conditions still less understood; and their variability at twilight, as well as in the zodiacal light, excite our astonishment. Yet the atmosphere which surrounds the earth is not thicker in proportion to the bulk of our globe than the line of a circle two inches in diameter when compared with the space which it encloses, or the down on the skin of a peach in comparison with the fruit inside.

COLOURS OF THE ATMOSPHERE.

Pure air is blue, because, according to Newton, the molecules of the air have the thickness necessary to reflect blue rays. When the sky is not perfectly pure, and the atmosphere is blended with perceptible vapours, the diffused light is mixed with a large proportion of white. As the moon is yellow, the blue of the air assumes somewhat of a greenish tinge, or, in other words, becomes blended with yellow.—*Letter from Arago to Humboldt; Cosmos*, vol. iii.

BEAUTY OF TWILIGHT.

This phenomenon is caused by the refraction of solar light enabling it to diffuse itself gradually over our hemisphere, obscured by the shades of night, long before the sun appears, even when that luminary is eighteen degrees below our horizon. It is towards the poles that this reflected splendour of the great luminary is longest visible, often changing the whole of the night into a magic day, of which the inhabitants of southern Europe can form no adequate conception.

HOW PASCAL WEIGHED THE ATMOSPHERE.

Pascal's treatise on the weight of the whole mass of air forms the basis of the modern science of Pneumatics. In order to prove that the mass of air presses by its weight on all the bodies which it surrounds, and also that it is elastic and compressible, he carried a balloon, half-filled with air, to the top of the Puy de Dome, a mountain about 500 toises above Clermont, in Auvergne. It gradually inflated itself as it ascended, and when it reached the summit it was quite full, and swollen as if fresh air had been blown into it; or, what is the same thing, it swelled in proportion as the weight of the column of air which pressed upon it was diminished. When again brought down it became more and more flaccid, and when it reached the bottom it resumed its original condition. In the nine chapters of which the treatise consists, Pascal shows that all the phenomena and effects hitherto ascribed to the horror of a vacuum arise from the weight of the mass of air; and after explaining the variable pressure of the atmosphere in different localities and in its different states, and the rise of water in pumps, he calculates that the whole mass of air round our globe weighs 8,983,889,440,000,000,000 French pounds. — *North-British Review*, No. 2.

It seems probable, from many indications, that the greatest height at which visible clouds *ever exist* does not exceed ten miles; at which height the density of the air is about an eighth part of what it is at the level of the sea.—*Sir John Herschel.*

VARIATIONS OF CLIMATE.

History informs us that many of the countries of Europe which now possess very mild winters, at one time experienced severe cold during this season of the year. The Tiber, at Rome, was often frozen over, and snow at one time lay for forty days in that city. The Euxine Sea was frozen over every winter during the time of Ovid, and the rivers Rhine and Rhone used to be frozen over so deep that the ice sustained loaded wagons. The waters of the Tiber, Rhine, and Rhone, now flow freely every winter; ice is unknown in Rome, and the waves of the Euxine dash their wintry foam uncrystallised upon the rocks. Some have ascribed these climate changes to agriculture—the cutting down of dense forests, the exposing of the unturned soil to the summer's sun, and the draining of great marshes. We do not believe that such great changes could be produced on the climate of any country by agriculture; and we are certain that no such theory can account for the contrary change of climate—from warm to cold winters—which history tells us has taken place in other countries than those named. Greenland received its name from the emerald herbage which once clothed its valleys and mountains; and its east coast, which is now inaccessible on account of perpetual ice heaped upon its shores, was in the eleventh century the seat of flourishing Scandinavian colonies, all trace of which is now lost. Cold Labrador was named Vinland by the Northmen, who visited it A.D. 1000, and were charmed with its then mild climate. The cause of these changes is an important inquiry.—*Scientific American.*

AVERAGE CLIMATES.

When we consider the numerous and rapid changes which take place in our climate, it is a remarkable fact, that *the mean temperature of a place remains nearly the same.* The winter may be unusually cold, or the summer unusually hot, while the mean temperature has varied even less than a degree. A very warm summer is therefore likely to be accompanied with a cold winter; and in general, if we have any long period of cold weather, we may expect a similar period at a higher temperature. In general, however, in the same locality the relative distribution over summer and winter undergoes comparatively small variations; therefore every point of the globe has an average climate, though it is occasionally disturbed by different atmospheric changes.—*North-British Review,* No. 49.

THE FINEST CLIMATE IN THE WORLD.

Humboldt regards the climate of the Caspian Sea as the most salubrious in the world: here he found the most delicious fruits that he saw during his travels; and such was the purity of the air, that polished steel would not tarnish even by night exposure.

THE PUREST ATMOSPHERES.

The cloudless purity and transparency of the atmosphere, which last for eight months at Santiago, in Chili, are so great, that Lieutenant Gilliss, with the first telescope ever constructed in America, having a diameter of seven inches, was clearly able to recognise the sixth star in the trapezium of Orion. If we are to rely upon the statements of the Rev. Mr. Stoddart, an American missionary, Oroomiah, in Persia, seems to be, in so far as regards the transparency of the atmosphere, the most suitable place in the world for an astronomical observatory. Writing to Sir John Herschel from that country, he mentions that he has been enabled to distinguish with the naked eye the satellites of Jupiter, the crescent of Venus, the rings of Saturn, and the constituent members of several double stars.

SEA-BREEZES AND LAND-BREEZES ILLUSTRATED.

When a fire is kindled on the hearth, we may, if we will observe the motes floating in the room, see that those nearest the chimney are the first to feel the draught and to obey it,—they are drawn into the blaze. The circle of inflowing air is gradually enlarged, until it is scarcely perceived in the remote parts of the room. Now the land is the hearth, the rays of the sun the fire, and the sea, with its cool and calm air, the room; and thus we have at our firesides the sea-breeze in miniature.

When the sun goes down, the fire ceases; then the dry land commences to give off its surplus heat by radiation, so that by nine or ten o'clock it and the air above it are cooled below the sea temperature. The atmosphere on the land thus becomes heavier than that on the sea, and consequently there is a wind seaward, which we call the land-breeze.—*Maury.*

SUPERIOR SALUBRITY OF THE WEST.

All large cities and towns have their best districts in the West;* which choice the French *savans*, Pelouze, Pouillet, Boussingault, and Elie de Beaumont, attribute to the law of atmospheric pressure. "When," say they, "the barometric column rises, smoke and pernicious emanations rapidly evaporate in space. On the contrary, smoke and noxious vapours remain in apartments, and on the surface of the soil. Now, of all winds, that which causes the greatest ascension of the barometric column is the east; and that which lowers it most is the west. When the latter blows, it carries with it to the eastern parts of the town all the deleterious gases from the west; and thus the inhabitants of the east have to support their own smoke and miasma, and those brought by western winds. When, on the contrary, the east wind blows, it purifies the air by causing to ascend the pernicious emanations which it cannot drive to the west. Consequently, the inhabitants of the west receive pure air, from whatever part of the horizon it may arrive; and as the west winds are most prevalent, they are the first to receive the air pure, and as it arrives from the country.

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* Not only at London, but at Paris, Vienna, Berlin, Turin, St. Petersburg, and almost every other capital in Europe; at Liege, Caen, Montpellier, Toulouse, and several other large towns,—wherever, in fact, there are not great local obstacles,—the tendency of the wealthier inhabitants to group themselves to the west is as strongly marked as in the British metropolis. At Pompeii, and other ancient towns, the same thing may be noticed; and where the local configuration of the town necessitates an increase in a different direction, the moment the obstacle ceases houses spread towards the west.

FERTILISATION OF CLOUDS.

As the navigator cruises in the Pacific Ocean among the islands of the trade-wind region, he sees gorgeous piles of cumuli, heaped up in fleecy masses, not only capping the island hills, but often overhanging the lowest islet of the tropics, and even standing above coral patches and hidden reefs; "a cloud by day," to serve as a beacon to the lonely mariner out there at sea, and to warn him of shoals and dangers which no lead nor seaman's eye has ever seen or sounded. These clouds, under favourable circumstances, may be seen gathering above the low coral island, preparing it for vegetation and fruitfulness in a very striking manner. As they are condensed into showers, one fancies that they are a sponge of the most exquisite and delicately elaborated material, and that he can see, as they "drop down their fatness," the invisible but bountiful hand aloft that is pressing and squeezing it out.—*Maury.*

BAROMETRIC MEASUREMENT.

We must not place too implicit a dependence on Barometrical Measurements. Ermann in Siberia, and Ross in the Antarctic Seas, have demonstrated the existence of localities on the earth's surface where a permanent depression of the barometer prevails to the astonishing extent of nearly an inch.

GIGANTIC BAROMETER.

In the Great Exhibition Building of 1851 was a colossal Barometer, the tube and scale reaching from the floor of the gallery nearly to the top of the building, and the rise and fall of the indicating fluid being marked by feet instead of by tenths of inches. The column of mercury, supported by the pressure of the atmosphere, communicated with a perpendicular tube of smaller bore, which contained a coloured fluid much lighter than mercury. When a diminution of atmospheric pressure occurred, the mercury in the large tube descended, and by its fall forced up the coloured fluid in the smaller tube; the fall of the one being indicated in a magnified ratio by the rise in the other.

THE ATMOSPHERE COMPARED TO A STEAM-ENGINE.

In this comparison, by Lieut. Maury, the South Seas themselves, in all their vast intertropical extent, are the boiler for the engine, and the northern hemisphere is its condenser. The mechanical power exerted by the air and the sun in lifting water from the earth, in transporting it from one place to another, and in letting it down again, is inconceivably great. The utilitarian who compares the water-power that the Falls of Niagâra would afford if applied to machinery is astonished at the number of figures which are required to express its equivalent in horse-power. Yet what is the horse-power of the Niagara, falling a few steps, in comparison with the horse-power that is required to lift up as high as the clouds and let down again all the water that is discharged into the sea, not only by this river, but by all the other rivers in the world? The calculation has been made by engineers; and according to it, the force of making and lifting vapour from each area of one acre that is included on the surface of the earth, is equal to the power of thirty horses; and for the whole of the earth, it is 800 times greater than all the water-power in Europe.

HOW DOES THE RAIN-MAKING VAPOUR GET FROM THE SOUTHERN INTO THE NORTHERN HEMISPHERE?

This comes with such regularity, that our rivers never go dry, and our springs fail not, because of the exact *compensation* of the grand machine of *the atmosphere.* It is exquisitely and wonderfully counterpoised. Late in the autumn of the north, throughout its winter, and in early spring, the sun is pouring his rays with the greatest intensity down upon the seas of the southern hemisphere; and this powerful engine, which we are contemplating, is pumping up the water there with the greatest activity; at the same time, the mean temperature of the entire southern hemisphere is about 10° higher than the northern. The heat which this heavy evaporation absorbs becomes latent, and with the moisture is carried through the upper regions of the atmosphere until it reaches our climates. Here the vapour is formed into clouds, condensed and precipitated; the heat which held their water in the state of vapour is set free, and becomes sensible heat; and it is that which contributes so much to temper our winter climate.

It clouds up in winter, turns warm, and we say we are going to have falling weather: that is because the process of condensation has already commenced, though no rain or snow may have fallen. Thus we feel this southern heat, that has been collected by the rays of the sun by the sea, been bottled away by the winds in the clouds of a southern summer, and set free in the process of condensation in our northern winter.

Thus the South Seas should supply mainly the water for the engine just described, while the northern hemisphere condenses it; we should, therefore, have more rain in the northern hemisphere. The rivers tell us that we have, at least on the land; for the great water-courses of the globe, and half the fresh water in the world, are found on the north side of the equator. This fact is strongly corroborative of this hypothesis. To evaporate water enough annually from the ocean to cover the earth, on the average, five feet deep with rain; to transport it from one zone to another; and to precipitate it in the right places at suitable times and in the proportions due,—is one of the offices of the grand atmospherical machine. This water is evaporated principally from the torrid zone. Supposing it all to come thence, we shall have encircling the earth a belt of ocean 3000 miles in breadth, from which this atmosphere evaporates a layer of water annually sixteen feet in depth. And to hoist up as high as the clouds, and lower down again, all the water, in a lake sixteen feet deep and 3000 miles broad and 24,000 long, is the yearly business of this invisible machinery. What a powerful engine is the atmosphere! and how nicely adjusted must be all the cogs and wheels and springs and *compensations* of this exquisite piece of machinery, that it never wears out nor breaks down, nor fails to do its work at the right time and in the right way!—*Maury.*

THE PHILOSOPHY OF RAIN.

To understand the philosophy of this beautiful and often sublime phenomenon, a few facts derived from observation and a long train of experiments must be remembered.

1. Were the atmosphere every where at all times at a uniform temperature, we should never have rain, or hail, or snow. The water absorbed by it in evaporation from the sea and the earth's surface would descend in an imperceptible vapour, or cease to be absorbed by the air when it was once fully saturated.

2. The absorbing power of the atmosphere, and consequently its capability to retain humidity, is proportionally greater in warm than in cold air.

3. The air near the surface of the earth is warmer than it is in the region of the clouds. The higher we ascend from the earth, the colder do we find the atmosphere. Hence tho perpetual snow on very high mountains in the hottest climate.

Now when, from continued evaporation, the air is highly saturated with vapour, though it be invisible and the sky cloudless, if its temperature is suddenly reduced by cold currents descending from above or rushing from a higher to a lower latitude, its capacity to retain moisture is diminished, clouds are formed, and the result is rain. Air condenses as it cools, and, like a sponge filled with water and compressed, pours out the water which its diminished capacity cannot hold. What but Omniscience could have devised such an admirable arrangement for watering the earth?

INORDINATE RAINY CLIMATE.

The climate of the Khasia mountains, which lie north-east from Calcutta, and are separated by the valley of the Burrampooter River from the Himalaya range, is remarkable for the inordinate fall of rain—the greatest, it is said, which has ever been recorded. Mr. Yule, an English gentleman, established that in the single month of August 1841 there fell 264 inches of rain, or 22 feet, of which 12½ feet fell in the space of five consecutive days. This astonishing fact is confirmed by two other English travellers, who measured 30 inches of rain in twenty-four hours, and during seven months above 500 inches. This great rain-fall is attributed to the abruptness of the mountains which face the Bay of Bengal, and the intervening flat swamps 200 miles in extent. The district of the excessive rain is extremely limited; and but a few degrees farther west, rain is said to be almost unknown, and the winter falls of snow to seldom exceed two inches.

HOW DOES THE NORTH WIND DRIVE AWAY RAIN?

We may liken it to a wet sponge, and the decrease of temperature to the hand that squeezes that sponge. Finally, reaching the cold latitudes, all the moisture that a dew-point of zero, and even far below, can extract, is wrung from it; and this air then commences "to return according to his circuits" as dry atmosphere. And here we can quote Scripture again: "The north wind driveth away rain." This is a meteorological fact of high authority and great importance in the study of the circulation of the atmosphere.—*Maury.*

SIZE OF RAIN-DROPS.

The Drops of Rain vary in their size, perhaps from the 25th to the ¼ of an inch in diameter. In parting from the clouds, they precipitate their descent till the increasing resistance opposed by the air becomes equal to their weight, when they continue to fall with uniform velocity. This velocity is, therefore, in a certain ratio to the diameter of the drops; hence thunder and other showers in which the drops are large pour down faster than a drizzling rain. A drop of the 25th part of an inch, in falling through the air, would, when it had arrived at its uniform velocity, only acquire a celerity of 11½ feet per second; while one of ¼ of an inch would equal a velocity of 33½ feet.—*Leslie.*

RAINLESS DISTRICTS.

In several parts of the world there is no rain at all. In the Old World there are two districts of this kind: the desert of Sahara in Africa, and in Asia part of Arabia, Syria, and Persia; the other district lies between north latitude 30° and 50°, and between 75° and 118° of east longitude, including Thibet, Gobiar Shama, and Mongolia. In the New World the rainless districts are of much less magnitude, occupying two narrow strips on the shores of Peru and Bolivia, and on the coast of Mexico and Guatemala, with a small district between Trinidad and Panama on the coast of Venezuela.

ALL THE RAIN IN THE WORLD.

The Pacific Ocean and the Indian Ocean may be considered as one sheet of water covering an area quite equal in extent to one half of that embraced by the whole surface of the earth; and the total annual fall of rain on the earth's surface is 186,240 cubic imperial miles. Not less than three-fourths of the vapour which makes this rain comes from this waste of waters; but, supposing that only half of this quantity, that is 93,120 cubic miles of rain, falls upon this sea, and that that much at least is taken up from it again as vapour, this would give 255 cubic miles as the quantity of water which is daily lifted up and poured back again into this expanse. It is taken up at one place, and rained down at another; and in this process, therefore, we have agencies for multitudes of partial and conflicting currents, all, in their set strength, apparently as uncertain as the winds.

The better to appreciate the operation of such agencies in producing currents in the sea, imagine a district of 255 square miles to be set apart in the midst of the Pacific Ocean as the scene of operations for one day; then conceive a machine capable of pumping up in the twenty-four hours all the water to the depth of one mile in this district. The machine must not only pump up and bear off this immense quantity of water, but it must discharge it again into the sea on the same day, but at some other place.

All the great rivers of America, Europe, and Asia are lifted up by the atmosphere, and flow in invisible streams back through the air to their sources among the hills; and through channels so regular, certain, and well defined, that the quantity thus conveyed one year with the other is nearly the same: for that is the quantity which we see running down to the ocean through these rivers; and the quantity discharged annually by each river is, as far as we can judge, nearly a constant.—*Maury.*

AN INCH OF RAIN ON THE ATLANTIC.

Lieutenant Maury thus computes the effect of a single Inch of Rain falling upon the Atlantic Ocean. The Atlantic includes an area of twenty-five millions of square miles. Suppose an inch of rain to fall upon only one-fifth of this vast expanse. It would weigh, says our author, three hundred and sixty thousand millions of tons: and the salt which, as water, it held in solution in the sea, and which, when that water was taken up as vapour, was left behind to disturb equilibrium, weighed sixteen millions more of tons, or nearly twice as much as all the ships in the world could carry at a cargo each. It might fall in an hour, or it might fall in a day; but, occupy what time it might in falling, this rain is calculated to exert so much force —which is inconceivably great—in disturbing the equilibrium of the ocean. If all the water discharged by the Mississippi river during the year were taken up in one mighty measure, and cast into the ocean at one effort, it would not make a greater disturbance in the equilibrium of the sea than would the fall of rain supposed. And yet so gentle are the operations of nature, that movements so vast are unperceived.

THE EQUATORIAL CLOUD-RING.

In crossing the Equatorial Doldrums, the voyager passes a ring of clouds that encircles the earth, and is stretched around our planet to regulate the quantity of precipitation in the rain-belt beneath it; to preserve the due quantum of heat on the face of the earth; to adjust the winds; and send out for distribution to the four corners vapours in proper quantities, to make up to each river-basin, climate, and season, its quota of sunshine, cloud, and moisture. Like the balance-wheel of a well-constructed chronometer, this cloud-ring affords the grand atmospherical machine the most exquisitely arranged *self-compensation.* Nature herself has hung a thermometer under this cloud-belt that is more perfect than any that man can construct, and its indications are not to be mistaken.—*Maury.*

"THE EQUATORIAL DOLDRUMS"

is another of these calm places. Besides being a region of calms and baffling winds, it is a region noted for its rains and clouds, which make it one of the most oppressive and disagreeable places at sea. The emigrant ships from Europe for Australia have to cross it. They are often baffled in it for two or three weeks; then the children and the passengers who are of delicate health suffer most. It is a frightful graveyard on the wayside to that golden land.

BEAUTY OF THE DEW-DROP.

The Dew-drop is familiar to every one from earliest infancy. Resting in luminous beads on the down of leaves, or pendent from the finest blades of grass, or threaded upon the floating lines of the gossamer, its "orient pearl" varies in size from the diameter of a small pea to the most minute atom that can be imagined to exist. Each of these, like the rain-drops, has the properties of reflecting and refracting light; hence, from so many minute prisms, the unfolded rays of the sun are sent up to the eye in colours of brilliancy similar to those of the rainbow. When the sunbeams traverse horizontally a very thickly-bedewed grass-plot, these colours arrange themselves so as to form an iris, or dew-bow; and if we select any one of these drops for observation, and steadily regard it while we gradually change our position, we shall find the prismatic colours follow each other in their regular order.—*Wells.*

FALL OF DEW IN ONE YEAR.

The annual average quantity of Dew deposited in this country is estimated at a depth of about five inches, being about one-seventh of the mean quantity of moisture supposed to be received from the atmosphere all over Great Britain in the year; or about 22,161,337,355 tons, taking the ton at 252 imperial gallons.—*Wells.*

GRADUATED SUPPLY OF DEW TO VEGETATION.

Each of the different grasses draws from the atmosphere during the night a supply of dew to recruit its energies dependent upon its form and peculiar radiating power. Every flower has a power of radiation of its own, subject to changes during the day and night, and the deposition of moisture on it is regulated by the peculiar law which this radiating power obeys; and this power will be influenced by the aspect which the flower presents to the sky, unfolding to the contemplative mind the most beautiful example of creative wisdom.*

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* By far the most complete set of experiments on the Radiation of Heat from the Earth's Surface at Night which have been published since Dr. Wells's Memoir *On Dew*, are those of Mr. Glaisher, F.R.S., *Philos. Trans.* for 1847.

WARMTH OF SNOW IN ARCTIC LATITUDES.

The first warm Snows of August and September (says Dr. Kane), falling on a thickly-bleached carpet of grasses, heaths, and willows, enshrine the flowery growths which nestle round them in a non-conducting air-chamber; and as each successive snow increases the thickness of the cover, we have, before the intense cold of winter sets in, a light cellular bed covered by drift, seven, eight, or ten feet deep, in which the plant retains its vitality. Dr. Kane has proved by experiments that the conducting power of the snow is proportioned to its compression by winds, rains, drifts, and congelation. The drifts that accumulate during nine months of the year are dispersed in well-defined layers of different density. We have first the warm cellular snows of fall, which surround the plant; next the finely-impacted snow-dust of winter; and above these the later humid deposits of spring. In the earlier summer, in the inclined slopes that face the sun, as the upper snow is melted and sinks upon the more compact layer below it is to a great extent arrested, and runs off like rain from a slope of clay. The plant reposes thus in its cellular bed, safe from the rush of waters, and protected from the nightly frosts by the icy roof above it.

IMPURITY OF SNOW.

It is believed that in ascending mountains difficult breathing is sooner felt upon snow than upon rock; and M. Boussingault, in his account of the ascent of Chimborazo, attributes this to the sensible deficiency of oxygen contained in the pores of the snow, which is exhaled when it melts. The fact that the air absorbed by snow is impure, was ascertained by De Saussure, and has been confirmed by Boussingault's experiments.—*Quarterly Review*, No. 202.

SNOW PHENOMENON.

Professor Dove of Berlin relates, in illustration of the formation of clouds of Snow over plains situated at a distance from the cooling summits of mountains, that on one occasion a large company had gathered in a ballroom in Sweden. It was one of those icy starlight nights which in that country are so aptly called "iron nights." The weather was clear and cold, and the ballroom was clear and warm; and the heat was so great, that several ladies fainted. An officer present tried to open a window; but it was frozen fast to the sill. As a last resort, he broke a pane of glass; the cold air rushed in, and it *snowed in the room.* A minute before all was clear; but the warm air of the room had sustained an amount of moisture in a transparent condition which it was not able to maintain when mixed with the colder air from without. The vapour was first condensed, and then frozen.

ABSENCE OF SNOW IN SIBERIA.

There is in Siberia, M. Ermann informs us, an *entire district* in which during the winter the sky is constantly clear, and where a single particle of snow never falls.—*Arago.*

ACCURACY OF THE CHINESE AS OBSERVERS.

The beautiful forms of snow-crystals have long since attracted Chinese observers; for from a remote period there has been met with in their conversation and books an axiomatic expression, to the effect that "snow-flakes are hexagonal," showing the Chinese to be accurate observers of nature.

PROTECTION AGAINST HAIL AND STORMS.

Arago relates, that when, in 1847, two small agricultural districts of Bourgoyne had lost by Hail crops to the value of a million and a half of francs, certain of the proprietors went to consult him on the means of protecting them from like disasters. Resting on the hypothesis of the electric origin of hail, Arago suggested the discharge of the electricity of the clouds by means of balloons communicating by a metallic wire with the soil. This project was not carried out; but Arago persisted in believing in the effectiveness of the method proposed.

Arago, in his *Meteorological Essays,* inquires whether the firing of cannon can dissipate storms. He cites several cases in its favour, and others which seem to oppose it; but he concludes by recommending it to his successors. Whilst Arago was propounding these questions, a person not conversant with science, the poet Méry, was collecting facts supporting the view, which he has published in his *Paris Futur.* His attention was attracted to the firing of cannon to dissipate storms in 1828, whilst an assistant in the "Ecole de Tir" at Vincennes. Having observed that there was never any rain in the morning of the exercise of firing, he waited to examine military records, and found there, as he says, facts which justified the expressions of "Le soleil d'Austerlitz," "Le soleil de juillet," upon the morning of the Revolution of July; and he concluded by proposing to construct around Paris twelve towers of great height, which he calls "tours imbrifuges," each carrying 100 cannons, which should be discharged into the air on the approach of a storm. About this time an incident occurred which in nowise confirmed the truth of M. Méry's theory. The 14th of August was a fine day. On the 15th, the fête of the Empire, the sun shone out, the cannon thundered all day long, fireworks and illuminations were blazing from nine o'clock in the evening. Every thing conspired to verify the hypothesis of M. Méry, and chase away storms for a long time. But towards eleven in the evening a torrent of rain burst upon Paris, in spite of the pretended influence of the discharge of cannon, and gave an occasion for the mobile Gallic mind to turn its attention in other directions.

TERRIFIC HAILSTORM.

Jansen describes, from the log-book of the *Rhijin*, Captain Brandligt, in the South-Indian Ocean (25° south latitude) a Hurricane, accompanied by Hail, by which several of the crew were made blind, others had their faces cut open, and those who were in the rigging had their clothes torn off them. The master of the ship compared the sea "to a hilly landscape in winter covered with snow." Does it not appear as if the "treasures of the hail" were opened, which were "reserved against the time of trouble, against the day of battle and war"?

HOW WATERSPOUTS ARE FORMED IN THE JAVA SEA.

Among the small groups of islands in this sea, in the day and night thunderstorms, the combat of the clouds appears to make them more thirsty than ever. In tunnel form, when they can no longer quench their thirst from the surrounding atmosphere, they descend near the surface of the sea, and appear to lap the water directly up with their black mouths. They are not always accompanied by strong winds; frequently more than one is seen at a time, whereupon the clouds whence they proceed disperse, and the ends of the Waterspouts bending over finally causes them to break in the middle. They seldom last longer than five minutes. As they are going away, the bulbous tube, which is as palpable as that of a thermometer, becomes broader at the base; and little clouds, like steam from the pipe of a locomotive, are continually thrown off from the circumference of the spout, and gradually the water is released, and the cloud whence the spout came again closes its mouth.

COLD IN HUDSON'S BAY.

Mr. R. M. Ballantyne, in his journal of six years' residence in the territories of the Hudson's Bay Company, tells us, that for part of October there is sometimes a little warm, or rather thawy, weather; but after that, until the following April, the thermometer seldom rises to the freezing point. In the depth of winter, the thermometer falls from 30° to 40°, 45°, and even 49° *below zero* of Fahrenheit. This intense cold is not, however, so much felt as one might suppose; for during its continuance the air is perfectly calm. Were the slightest breath of wind to rise when the thermometer stands so low, no man could show his face to it for a moment. Forty degrees below zero, and quite calm, is infinitely preferable to fifteen below, or thereabout, with a strong breeze of wind. Spirit of wine is, of course, the only thing that can be used in the thermometer; as mercury, were it exposed to such cold, would remain frozen nearly half the winter. Spirit never froze in any cold ever experienced at York Factory, unless when very much adulterated with water; and even then the spirit would remain liquid in the centre of the mass. Quicksilver easily freezes in this climate, and it has frequently been run into a bullet-mould, exposed to the cold air till frozen, and in this state rammed down a gun-barrel, and fired through a thick plank. The average cold may be set down at about 15° or 16° below zero, or 48° of frost. The houses at the Bay are built of wood, with double windows and doors. They are heated by large iron stoves, fed with wood; yet so intense is the cold, that when a stove has been in places red-hot, a basin of water in the room has been frozen solid.

PURITY OF WENHAM-LAKE ICE.

Professor Faraday attributes the purity of Wenham-Lake Ice to its being free from air-bubbles and from salts. The presence of the first makes it extremely difficult to succeed in making a lens of English ice which will concentrate the solar rays, and readily fire gunpowder; whereas nothing is easier than to perform this singular feat of igniting a combustible body by aid of a frozen mass if Wenham-Lake ice be employed. The absence of salts conduces greatly to the permanence of the ice; for where water is so frozen that the salts expelled are still contained in air-cavities and cracks, or form thin films between the layers of ice, these entangled salts cause the ice to melt at a lower temperature than 32°, and the liquefied portions give rise to streams and currents within the body of the ice which rapidly carry heat to the interior. The mass then goes on thawing within as well as without, and at temperatures below 32°; whereas pure, compact, Wenham-Lake ice can only thaw at 32°, and only on the outside of the mass.—*Sir Charles Lyell's Second Visit to the United States.*

ARCTIC TEMPERATURES.

Dr. Kane, in his Second Arctic Expedition, found the thermometers beginning to show unexampled temperature: they ranged from 60° to 70° below zero, and upon the taffrail of the brig 65°. The reduced mean of the best spirit-standards gave 67° or 99° below the freezing point of water. At these temperatures chloric ether became solid, and chloroform exhibited a granular pellicle on its surface. Spirit of naphtha froze at 54°, and the oil of turpentine was solid at 63° and 65°.

DR. RAE'S ARCTIC EXPLORATIONS.

The gold medal of the Royal Geographical Society was in 1852 most rightfully awarded to this indefatigable Arctic explorer. His survey of the inlet of Boothia, in 1848, was unique in its kind. In Repulse Bay he maintained his party on deer, principally shot by himself; and spent ten months of an Arctic winter in a hut of stones, with no other fuel than a kind of hay of the *Andromeda tetragona.* Thus he preserved his men to execute surveying journeys of 1000 miles in the spring. Later he travelled 300 miles on snow-shoes. In a spring journey over the ice, with a pound of fat daily for fuel, accompanied by two men only, and trusting solely for shelter to snow-houses, which he taught his men to build, he accomplished 1060 miles in thirty-nine days, or twenty-seven miles per day, including stoppages,—a feat never equalled in Arctic travelling. In the spring journey, and that which followed in the summer in boats, 1700 miles were traversed in eighty days. Dr. Rae's greatest sufferings, he once remarked to Sir George Back, arose from his being obliged to sleep upon his frozen mocassins in order to thaw them for the morning's use.

PHENOMENA OF THE ARCTIC CLIMATE.

Sir John Richardson, in his history of his Expedition to these regions, describes the power of the sun in a cloudless sky to have been so great, that he was glad to take shelter in the water while the crews were engaged on the portages; and he has never felt the direct rays of the sun so oppressive as on some occasions in the high latitudes. Sir John observes:

> The rapid evaporation of both snow and ice in the winter and spring, long before the action of the sun has produced the slightest thaw or appearance of moisture, is evident by many facts of daily occurrence. Thus when a shirt, after being washed, is exposed in the open air to a temperature of from 40° to 50° below zero, it is instantly rigidly frozen, and may be broken if violently bent. If agitated when in this condition by a strong wind, it makes a rustling noise like theatrical thunder.
>
> In consequence of the extreme dryness of the atmosphere in winter, most articles of English manufacture brought to Rupert's Land are shrivelled, bent, and broken. The handles of razors and knives, combs, ivory scales, &c., kept in the warm room, are changed in this way. The human body also becomes vividly electric from the dryness of the skin. One cold night I rose from my bed, and was going out to observe the thermometer, with no other clothing than my flannel night-dress, when on my hand approaching the iron latch of the door, a distinct spark was elicited. Friction of the skin at almost all times in winter produced the electric odour.
>
> Even at midwinter we had but three hours and a half of daylight. On December 20th I required a candle to write at the window at ten in the morning. The sun was absent ten days, and its place in the heavens

at noon was denoted by rays of light shooting into the sky above the woods.

The moon in the long nights was a most beautiful object, that satellite being constantly above the horizon for nearly a fortnight together. Venus also shone with a brilliancy which is never witnessed in a sky loaded with vapours; and, unless in snowy weather, our nights were always enlivened by the beams of the aurora.

INTENSE HEAT AND COLD OF THE DESERT.

Among crystalline bodies, rock-crystal, or silica, is the best conductor of heat. This fact accounts for the steadiness of temperature in one set district, and the extremes of Heat and Cold presented by day and night on such sandy wastes as the Sahara. The sand, which is for the most part silica, drinks-in the noon-day heat, and loses it by night just as speedily.

The influence of the hot winds from the Sahara has been observed in vessels traversing the Atlantic at a distance of upwards of 1100 geographical miles from the African shores, by the coating of impalpable dust upon the sails.

TRANSPORTING POWER OF WINDS.

The greatest example of their power is the *sand-flood* of Africa, which, moving gradually eastward, has overwhelmed all the land capable of tillage west of the Nile, unless sheltered by high mountains, and threatens ultimately to obliterate the rich plain of Egypt.

EXHILARATION IN ASCENDING MOUNTAINS.

At all elevations of from 6000 to 11,000 feet, and not unfrequently for even 2000 feet more, the pedestrian enjoys a pleasurable feeling, imparted by the consciousness of existence, similar to that which is described as so fascinating by those who have become familiar with the desert-life of the East. The body seems lighter, the nervous power greater, the appetite is increased; and fatigue, though felt for a time, is removed by the shortest repose. Some travellers have described the sensation by the impression that they do not actually press the ground, but that the blade of a knife could be inserted between the sole of the foot and the mountain top.—*Quarterly Review*, No. 202.

TO TELL THE APPROACH OF STORMS.

The proximity of Storms has been ascertained with accuracy by various indications of the electrical state of the atmosphere. Thus Professor Scott, of Sandhurst College, observed in Shetland that drinking-glasses, placed in an inverted position upon a shelf in a cupboard on the ground-floor of Belmont House, occasionally emitted sounds as if they were tapped with a knife, or raised a little and then let fall on the shelf. These sounds preceded wind; and when they occurred, boats and vessels were immediately secured. The strength of the sound is said to be proportioned to the tempest that follows.

REVOLVING STORMS.

By the conjoint labours of Mr. Redfield, Colonel Reid, and Mr. Piddington, on the origin and nature of hurricanes, typhoons, or revolving storms, the following important results have been obtained. Their existence in moderate latitudes on both sides the equator; their absence in the immediate neighbourhood of the equatorial regions; and the fact, that while in the northern latitudes these storms revolve in a direction contrary to the hands of a watch the face of which is placed upwards, in the southern latitudes they rotate in the opposite direction,—are shown to be so many additions to the long chain of evidence by which the rotation of the earth as a physical fact is demonstrated.

IMPETUS OF A STORM.

Captain Sir S. Brown estimates, from experiments made by him at the extremity of the Brighton-Chain Pier in a heavy south-west gale, that the waves impinge on a cylindrical surface one foot high and one foot in diameter with a force equal to eighty pounds, to which must be added that of the wind, which in a violent storm exerts a pressure of forty pounds. He computed the collective impetus of the waves on the lower part of a lighthouse proposed to be built on the Wolf Rock (exposed to the most violent storms of the Atlantic), of the surf on the upper part, and of the wind on the whole, to be equal to 100 tons.

HOW TO MAKE A STORM-GLASS.

This instrument consists of a glass tube, sealed at one end, and furnished with a brass cap at the other end, through which the air is admitted by a very small aperture. Nearly fill the tube with the following solution: camphor, 2½ drams; nitrate of potash, 38 grains; muriate of ammonia, 38 grains; water, 9 drams; rectified spirit, 9 drams. Dissolve with heat. At the ordinary temperature of the atmosphere, plumose crystals are formed. On the approach of stormy weather, these crystals appear compressed into a compact mass at the bottom of the tube; while during fine weather they assume their plumose character, and extend a considerable way up the glass. These results depend upon the condition of the air, but they are not considered to afford any reliable indication of approaching weather.

SPLENDOUR OF THE AURORA BOREALIS.

Humboldt thus beautifully describes this phenomenon :

> The intensity of this light is at times so great, that Lowenörn (on June 29, 1786) recognised its coruscation in bright sunshine. Motion renders the phenomenon more visible. Round the point in the vault of heaven which corresponds to the direction of the inclination of the needle the beams unite together to form the so-called corona, the crown of the Northern Light, which encircles the summit of the heavenly canopy with a milder radiance and unflickering emanations of light. It is only in rare instances that a perfect crown or circle is formed ; but on its completion, the phenomenon has invariably reached its maximum, and the radiations become less frequent, shorter, and more colourless. The crown, and the luminous arches break up; and the whole vault of heaven becomes covered with irregularly scattered, broad, faint, almost ashy-gray, luminous, immovable patches, which in their turn disappear, leaving nothing but a trace of a dark smoke-like segment on the horizon. There often remains nothing of the whole spectacle but a white delicate cloud with feathery edges, or divided at equal distances into small roundish groups like cirro-cumuli —*Cosmos,* vol. i.

Among many theories of this phenomenon is that of Lieutenant Hooper, R.N., who has stated to the British Association that he believes " the Aurora Borealis to be no more nor less than the moisture in some shape (whether dew or vapour, liquid or frozen), illuminated by the heavenly bodies, either directly, or reflecting their rays from the frozen masses around the Pole, or even from the immediately proximate snow-clad earth."

VARIETIES OF LIGHTNING.

According to Arago's investigations, the evolution of Lightning is of three kinds : zigzag, and sharply defined at the edges; in sheets of light, illuminating a whole cloud, which seems to open and reveal the light within it ; and in the form of fire-balls. The duration of the first two kinds scarcely continues the thousandth part of a second ; but the globular lightning moves much more slowly, remaining visible for several seconds.

WHAT IS SHEET-LIGHTNING ?

This electric phenomenon is unaccompanied by thunder, or too distant to be heard : when it appears, the whole sky, but particularly the horizon, is suddenly illuminated with a flickering flash. Philosophers differ much as to its cause. Matteucci supposes it to be produced either during evaporation, or evolved (according to Pouillet's theory) in the process of vegetation ; or generated by chemical action in the great laboratory of nature, the earth, and accumulated in the lower strata of the air in consequence of the ground being an imperfect conductor.

Arago and Kamtz, however, consider sheet-lightning as *reflections* *of distant thunderstorms.* Saussure observed sheet-lightning in the direction of Geneva, from the Hospice du Grimsel, on the 10th and 11th of July 1783; while at the same time a terrific thunderstorm raged at Geneva. Howard, from Tottenham, near London, on July 31, 1813, saw sheet-lightning towards the south-east, while the sky was bespangled with stars, not a cloud floating in the air; at the same time a thunderstorm raged at Hastings, and in France from Calais to Dunkirk. Arago supports his opinion, that the phenomenon is *reflected lightning*, by the following illustration: In 1803, when observations were being made for determining the longitude, M. de Zach, on the Brocken, used a few ounces of gunpowder as a signal, the flash of which was visible from the Klenlenberg, sixty leagues off, although these mountains are invisible from each other.

PRODUCTION OF LIGHTNING BY RAIN.

A sudden gust of rain is almost sure to succeed a violent detonation immediately overhead. Mr. Birt, the meteorologist, asks: Is this rain a *cause* or *consequence* of the electric discharge? To this he replies:

In the sudden agglomeration of many minute and feebly electrified globules into one rain-drop, the quantity of electricity is increased in a greater proportion than the surface over which (according to the laws of electric distribution) it is spread. By tension, therefore, it is increased, and may attain the point when it is capable of separating from the *drop* to seek the surface of the *cloud*, or of the newly-formed descending body of rain, which, under such circumstances, may be regarded as a conducting medium. Arrived at this surface, the tension, for the same reason, becomes enormous, and a flash escapes. This theory Mr. Birt has confirmed by observation of rain in thunderstorms.

SERVICE OF LIGHTNING-CONDUCTORS.

Sir David Brewster relates a remarkable instance of a tree in Clandeboye Park, in a thick mass of wood, and *not the tallest of the group*, being struck by lightning, which passed down the trunk into the ground, rending the tree asunder. This shows that an object may be struck by lightning in a locality where there are numerous conducting points more elevated than itself; and at the same time proves that lightning cannot be diverted from its course by lofty isolated conductors, but that the protection of buildings from this species of meteor can only be effected by conductors stretching out in all directions.

Professor Silliman states, that lightning-rods cannot be relied upon unless they reach the earth where it is permanently wet; and that the best security is afforded by carrying the rod, or some good metallic conductor duly connected with it, to the water in the well, or to some other water that never fails. The professor's house, it seems, was struck; but his lightning-rods were not more than two or three inches in the ground, and were therefore virtually of no avail in protecting the building.

ANCIENT LIGHTNING-CONDUCTOR.

Humboldt informs us, that "the most important ancient notice of the relations between lightning and conducting metals is that of Ctesias, in his *Indica,* cap. iv. p 190. He possessed two iron swords, presents from the king Artaxerxes Mnemon and from his mother Parasytis, which, when planted in the earth, averted clouds, hail, and *strokes of lightning.* He had himself seen the operation, for the king had twice made the experiment before his eyes."—*Cosmos,* vol. ii.

THE TEMPLE OF JERUSALEM PROTECTED FROM LIGHTNING.

We do not learn, either from the Bible or Josephus, that the Temple at Jerusalem was ever struck by Lightning during an interval of more than a thousand years, from the time of Solomon to the year 70; although, from its situation, it was completely exposed to the violent thunderstorms of Palestine.

By a fortuitous circumstance, the Temple was crowned with lightning-conductors similar to those which we now employ, and which we owe to Franklin's discovery. The roof, constructed in what we call the Italian manner, and covered with boards of cedar, having a thick coating of gold, was garnished from end to end with long pointed and gilt iron or steel lances, which, Josephus says, were intended to prevent birds from roosting on the roof and soiling it. The walls were overlaid throughout with wood, thickly gilt. Lastly, there were in the courts of the Temple cisterns, into which the rain from the roof was conducted by *metallic pipes.* We have here both the lightning-rods and a means of conduction so abundant, that Lichtenberg is quite right in saying that many of the present apparatuses are far from offering in their construction so satisfactory a combination of circumstances.—*Abridged from Arago's Meteorological Essays.*

HOW ST. PAUL'S CATHEDRAL IS PROTECTED FROM LIGHTNING.

In March 1769, the Dean and Chapter of St. Paul's addressed a letter to the Royal Society, requesting their opinion as to the best and most effectual method of fixing electrical conductors on the cathedral. A committee was formed for the purpose, and Benjamin Franklin was one of the members; their report was made, and the conductors were fixed as follows:

The seven iron scrolls supporting the ball and cross are connected with other rods (used merely as conductors), which unite them with several large bars, descending obliquely to the stone-work of the lantern, and connected by an iron ring with four other iron bars to the lead covering of the great cupola, a distance of forty-eight feet; thence the communication is continued by the rain-water pipes to the lead-covered roof, and thence by lead water-pipes which pass into the earth ; thus completing the entire communication from the cross to the ground, partly through iron, and partly through lead. On the clock-tower a bar of iron connects the pine-apple at the top with the iron staircase, and thence with the lead on the roof of the church. The bell-tower is similarly protected. By these means the metal used in the building is made available as conductors; the metal employed merely for that purpose being exceedingly small in quantity.—*Curiosities cf London.*

VARIOUS EFFECTS OF LIGHTNING.

Dr. Hibbert tells us that upon the western coast of Scotland and Ireland, Lightning coöperates with the violence of the storm in shattering solid rocks, and heaping them in piles of enormous fragments, both on dry land and beneath the water.

Euler informs us, in his *Letters to a German Princess*, that he corresponded with a Moravian priest named Divisch, who assured him that he had averted during a whole summer every thunderstorm which threatened his own habitation and the neighbourhood, by means of a machine constructed upon the principles of electricity; that the machinery sensibly attracted the clouds, and constrained them to descend quietly in a distillation, without any but a very distant thunderclap. Euler assures us that "the fact is undoubted, and confirmed by irresistible proof."

About the year 1811, in the village of Phillipsthal, in Eastern Prussia, an attempt was made to split an immense stone into a multitude of pieces by means of lightning. A bar of iron, in the form of a conductor, was previously fixed to the stone; and the experiment was attended with complete success; for during the very first thunderstorm the lightning burst the stone without displacing it.

The celebrated Duhamel du Monceau says, that lightning, unaccompanied by thunder, wind, or rain, has the property of breaking oat-stalks. The farmers are acquainted with this effect, and say that the lightning breaks down the oats. This is a well-received opinion with the farmers in Devonshire.

Lightning has in some cases the property of reducing solid bodies to ashes, or to pulverisation,—even the human body,—without there being any signs of heat. The effects of lightning on paralysis are very remarkable, in some cases curing, in others causing, that disease.

The returning stroke of lightning is well known to be due to the restoration of the natural electric state, after it has been disturbed by induction.

A THUNDERSTORM SEEN FROM A BALLOON.

Mr. John West, the American aeronaut, in his observations made during his numerous ascents, describes a storm viewed from above the clouds to have the appearance of ebullition The bulging upper surface of the cloud resembles a vast sea of boiling and upheaving snow; the noise of the falling rain is like that of a waterfall over a precipice; the thunder above the cloud is not loud, and the flashes of lightning appear like streaks of intensely white fire on a surface of white vapour. He thus describes a side view of a storm which he witnessed June 3, 1852, in his balloon excursion from Portsmouth, Ohio:

> Although the sun was shining on me, the rain and small hail were rattling on the balloon. A rainbow, or prismatically-coloured arch or horse-shoe, was reflected against the sun; and as the point of observation changed laterally and perpendicularly, the perspective of this golden grotto changed its hues and forms. Above and behind this arch was going on the most terrific thunder; but no zigzag lightning was perceptible, only bright flashes, like explosions of "Roman candles" in fireworks. Occasionally there was a zigzag explosion in the cloud immediately below, the thunder sounding like a *feu-de-joie* of a rifle-corps. Then an orange-coloured wave of light seemed to fall from the upper to the lower cloud; this was "still-lightning." Meanwhile intense electrical action was going on *in the balloon*, such as expansion, tremulous tension, lifting papers ten feet out of the car below the balloon and then dropping them, &c. The close view of this Ohio storm was truly sublime; its rushing noise almost appalling.

Ascending from the earth with a balloon, in the rear of a storm, and mounted up a thousand feet above it, the balloon will soon override the storm, and may descend in advance of it. Mr. West has experienced this several times.

REMARKABLE AERONAUTIC VOYAGE.

Mr. Sadler, the celebrated aeronaut, ascended on one occasion in a balloon from Dublin, and was wafted across the Irish Channel; when, on his approach to the Welsh coast, the balloon descended nearly to the surface of the sea. By this time the sun was set, and the shades of evening began to close in. He threw out nearly all his ballast, and suddenly sprang upward to a great height; and by so doing brought his horizon to *dip* below the sun, producing the whole phenomenon of a western sunrise. Subsequently descending in Wales, he of course witnessed a second sunset on the same evening.—*Sir John Herschel's Outlines of Astronomy.*

Physical Geography of the Sea.*

CLIMATES OF THE SEA.

The fauna and flora of the Sea are as much the creatures of Climate, and are as dependent for their well-being upon temperature, as are the fauna and flora of the dry land. Were it not so, we should find the fish and the algæ, the marine insect and the coral, distributed equally and alike in all parts of the ocean; the polar whale would delight in the torrid zone; and the habitat of the pearl oyster would be also under the iceberg, or in frigid waters colder than the melting ice.

THE CIRCULATION OF THE SEA.

The coral islands, reefs, and beds with which the Pacific Ocean is studded and garnished, were built up of materials which a certain kind of insect quarried from the sea-water. The currents of the sea ministered to this little insect; they were its *hod-carriers.* When fresh supplies of solid matter were wanted for the coral rock upon which the foundations of the Polynesian Islands were laid, these hod-carriers brought them in unfailing streams of sea-water, loaded with food and building-materials for the coralline: the obedient currents thread the widest and the deepest sea. Now we know that its adaptations are suited to all the wants of every one of its inhabitants,—to the wants of the coral insect as well as those of the whale. Hence *we know* that the sea has its system of circulation: for it transports materials for the coral rock from one part of the world to another; its currents receive them from rivers, and hand them over to the little mason for the structure of the most stupendous works of solid masonry that man has ever seen—the coral islands of the sea.

TEMPERATURE OF THE SEA.

Between the hottest hour of the day and the coldest hour of the night there is frequently a change of four degrees in the Temperature of the Sea. Taking one-fifth of the Atlantic Ocean for the scene of operation, and the difference of four degrees to extend only ten feet below the surface, the total and absolute change made in such a mass of sea-water, by altering its temperature two degrees, is equivalent to a change in its volume of 390,000,000 cubic feet.

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* The author is largely indebted for the illustrations in this new field of research to Lieutenant Maury's valuable work, *The Physical Geography of the Sea*, Sixth edition. Harper, New York; Low, Son, and Co., London.

TRANSPARENCY OF THE OCEAN.

Captain Glynn, U.S.N., has made some interesting observations, ranging over 200° of latitude, in different oceans, in very high latitudes, and near the equator. His apparatus was simple: a common white dinner-plate, slung so as to lie in the water horizontally, and sunk by an iron pot with a line. Numbering the fathoms at which the plate was visible below the surface, Captain Glynn saw it on two occasions, at the maximum, twenty-five fathoms (150 feet) deep; the water was extraordinarily clear, and to lie in the boat and look down was like looking down from the mast-head; and the objects were clearly defined to a great depth.

THE BASIN OF THE ATLANTIC.

In its entire length, the basin of this sea is a long trough, separating the Old World from the New, and extending probably from pole to pole.

This ocean-furrow was scored into the solid crust of our planet by the Almighty hand, that there the waters which "he called seas" might be gathered together so as to "let the dry land appear," and fit the earth for the habitation of man.

From the top of Chimborazo to the bottom of the Atlantic, at the deepest place yet recognised by the plummet in the North Atlantic, the distance in a vertical line is nine miles.

Could the waters of the Atlantic be drawn off, so as to expose to view this great sea-gash, which separates continents, and extends from the Arctic to the Antarctic, it would present a scene the most grand, rugged, and imposing. The very ribs of the solid earth, with the foundations of the sea, would be brought to light; and we should have presented to us at one view, in the empty cradle of the ocean, "a thousand fearful wrecks," with that dreadful array of dead men's skulls, great anchors, heaps of pearls and inestimable stones, which, in the dreamer's eye, lie scattered on the bottom of the sea, making it hideous with sights of ugly death.

GALES OF THE ATLANTIC.

Lieutenant Maury has, in a series of charts of the North and South Atlantic, exhibited, by means of colours, the prevalence of Gales over the more stormy parts of the oceans for each month in the year. One colour shows the region in which there is a gale every six days; another colour every six to ten days; another every ten to fourteen days: and there is a separate chart for each month and each ocean.

SOLITUDE AT SEA.

Between Humboldt's Current of Peru and the great equatorial flow, there is "a desolate region," rarely visited by the whale, either sperm or right. Formerly this part of the ocean was seldom whitened by the sails of a ship, or enlivened by the presence of man. Neither the industrial pursuits of the sea nor the highways of commerce called him into it. Now and then a roving cruiser or an enterprising whalesman passed that way; but to all else it was an unfrequented part of the ocean, and so remained until the gold-fields of Australia and the guano islands of Peru made it a thoroughfare. All vessels bound from Australia to South America now pass through it; and in the journals of some of them it is described as a region almost void of the signs of life in both sea and air. In the South-Pacific Ocean especially, where there is such a wide expanse of water, sea-birds often exhibit a companionship with a vessel, and will follow and keep company with it through storm and calm for weeks together. Even the albatross and Cape pigeon, that delight in the stormy regions of Cape Horn and the inhospitable climates of the Antarctic regions, not unfrequently accompany vessels into the perpetual summer of the tropics. The sea-birds that join the ship as she clears Australia will, it is said, follow her to this region, and then disappear. Even the chirp of the stormy petrel ceases to be heard here, and the sea itself is said to be singularly barren of "moving creatures that have life."

BOTTLES AND CURRENTS AT SEA.

Seafaring people often throw a bottle overboard, with a paper stating the time and place at which it is done. In the absence of other information as to Currents, that afforded by these mute little navigators is of great value. They leave no track behind them, it is true, and their routes cannot be ascertained; but knowing where they are cast, and seeing where they are found, some idea may be formed as to their course. Straight lines may at least be drawn, showing the shortest distance from the beginning to the end of their voyage, with the time elapsed. Admiral Beechey has prepared a chart, representing, in this way, the tracks of more than 100 bottles. From this it appears that the waters from every quarter of the Atlantic tend towards the Gulf of Mexico and its stream. Bottles cast into the sea midway between the Old and the New

Worlds, near the coasts of Europe, Africa, and America at the extreme north or farthest south, have been found either in the West Indies, or the British Isles, or within the well-known range of Gulf-Stream waters.

"THE HORSE LATITUDES"

are the belts of calms and light airs which border the polar edge of the north-east trade-winds. They are so called from the circumstance that vessels formerly bound from New England to the West Indies, with a deck-load of horses, were often so delayed in this calm belt of Cancer, that, from the want of water for their animals, they were compelled to throw a portion of them overboard.

"WHITE WATER" AND LUMINOUS ANIMALS AT SEA.

Captain Kingman, of the American clipper-ship *Shooting Star*, in lat. 8° 46′ S., long. 105° 30′ E., describes a patch of *white water*, about twenty-three miles in length, making the whole ocean appear like a plain covered with snow. He filled a 60-gallon tub with the water, and found it to contain small luminous particles seeming to be alive with worms and insects, resembling a grand display of rockets and serpents seen at a great distance in a dark night; some of the serpents appearing to be six inches in length, and very luminous. On being taken up, they emitted light until brought within a few feet of a lamp, when nothing was visible; but by aid of a sextant's magnifier they could be plainly seen—a jelly-like substance, without colour. A specimen two inches long was visible to the naked eye; it was about the size of a large hair, and tapered at the ends. By bringing one end within about one-fourth of an inch of a lighted lamp, the flame was attracted towards it, and burned with a red light; the substance crisped in burning, something like hair, or appeared of a red heat before being consumed. In a glass of the water there were several small round substances (say $\frac{1}{16}$th of an inch in diameter) which had the power of expanding and contracting; when expanded, the outer rim appeared like a circular saw, the teeth turned inward.

The scene from the clipper's deck was one of awful grandeur: the sea having turned to phosphorus, and the heavens being hung in blackness, and the stars going out, seemed to indicate that all nature was preparing for that last grand conflagration which we are taught to believe will annihilate this material world.

INVENTION OF THE LOG.

Long before the introduction of the Log, hour-glasses were used to tell the distance in sailing. Columbus, Juan de la Cosa, Sebastian Cabot, and Vasco de Gama, were not acquainted with the Log and its mode of application; and they estimated the ship's speed merely by the eye, while they found the distance they had made by the running-down of the sand in the *ampotellas*, or hour-glasses. The Log for the measurement of the distance traversed is stated by writers on navigation not to have been invented until the end of the sixteenth or the beginning of the seventeenth century (see *Encyclopædia Britannica*, 7th edition, 1842). The precise date is not known; but it is certain that Pigafetta, the companion of Magellan, speaks, in 1521, of the Log as a well-known means of finding the course passed over. Navarete places the use of the log-line in English ships in 1577.

LIFE OF THE SEA-DEEPS.

The ocean teems with life, we know. Of the four elements of the old philosophers,—fire, earth, air, and water,—perhaps the sea most of all abounds with living creatures. The space occupied on the surface of our planet by the different families of animals and their remains is inversely as the size of the individual; the smaller the animal, generally speaking, the greater the space occupied by his remains. Take the elephant and his remains, and a microscopic animal and his, and compare them; the contrast as to space occupied is as striking as that of the coral reef or island with the dimensions of the whale. The graveyard that would hold the corallines, is larger than the graveyard that would hold the elephants.

DEPTHS OF OCEAN AND AIR UNKNOWN.

At some few places under the tropics, no bottom has been found with soundings of 26,000 feet, or more than four miles; whilst in the air, if, according to Wollaston, we may assume that it has a limit from which waves of sound may be reverberated, the phenomenon of twilight would incline us to assume a height at least nine times as great. The aerial ocean rests partly on the solid earth, whose mountain-chains and elevated plateaus rise like green wooded shoals, and partly on the sea, whose surface forms a moving base, on which rest the lower, denser, and more saturated strata of air.—*Humboldt's Cosmos*, vol. i.

The old Alexandrian mathematicians, on the testimony of Plutarch, believed the depth of the sea to depend on the height of the mountains. Mr. W. Darling has propounded to the British Association the theory, that as the sea covers three times the area of the land, so it is reasonable to suppose that the depth of the ocean, and that for a large portion, is three times as great as the height of the highest mountain. Recent soundings show depths in the sea much greater than any elevations on the surface of the earth; for a line has been veered to the extent of seven miles.—*Dr. Scoresby.*

GREATEST ASCERTAINED DEPTH OF THE SEA.

In the dynamical theory of the tides, the ratio of the effects of the sun and moon depends, not only on the masses, distances, and periodic times of the two luminaries, but also on the Depth of the Sea; and this, accordingly, may be computed when the other quantities are known. In this manner Professor Haughton has deduced, from the solar and lunar co-efficients of the diurnal tide, a mean depth of 5·12 miles; a result which accords in a remarkable manner with that inferred from the ratio of the semi-diurnal co-efficients as obtained by Laplace from the Brest observations. Professor Hennessey states, that from what is now known regarding the depth of the ocean, the continents would appear as plateaus elevated above the oceanic depressions to an amount which, although small compared to the earth's radius, would be considerable when compared to its outswelling at the equator and its flattening towards the poles; and the surface thus presented would be the true surface of the earth.

The greatest depths at which the bottom of the sea has been reached with the plummet are in the North-Atlantic Ocean; and the places where it has been fathomed (by the United-States deep-sea sounding apparatus) do not show it to be deeper than 25,000 feet = 4 miles, 1293 yards, 1 foot. The deepest place in this ocean is probably between the parallels of 35° and 40° north latitude, and immediately to the southward of the Grand Banks of Newfoundland.

It appears that, with one exception, the bottom of the North-Atlantic Ocean, as far as examined, from the depth of about sixty fathoms to that of more than two miles (2000 fathoms), is literally nothing but a mass of microscopic shells. Not one of the animalcules from these shells has been found living in the surface-waters, nor in shallow water along the shore. Hence arises the question, Do they live on the bottom, at the immense depths where the shells are found; or are they borne by submarine currents from their real habitat?

RELATIVE LEVELS OF THE RED SEA AND MEDITERRANEAN.

The French engineers, at the beginning of the present century, came to the conclusion that the Red Sea was about thirty feet above the Mediterranean: but the observations of Mr. Robert Stephenson, the English engineer, at Suez; of M. Negretti, the Austrian, at Tineh, near the ancient Pelusium; and the levellings of Messrs. Talabat, Bourdaloue, and their assistants between the two seas;—have proved that the low-water mark of ordinary tides at Suez and Tineh is very nearly on the same levels, the difference being that at Suez it is rather more than one inch lower.—*Leonard Horner; Proceedings of the Royal Society*, 1855.

THE DEPTH OF THE MEDITERRANEAN.

Soundings made in the Mediterranean suffice to indicate depths equal to the average height of the mountains girding round this great basin; and, if one particular experiment may be credited, reaching even to 15,000 feet—an equivalent to the elevation of the highest Alps. This sounding was made about ninety miles east of Malta. Between Cyprus and Egypt, 6000 feet of line had been let down without reaching the bottom. Other deep soundings have been made in other places with similar results. In the lines of sea between Egypt and the Archipelago, it is stated that one sounding made by the *Tartarus* between Alexandria and Rhodes reached bottom at the depth of 9900 feet; another, between Alexandria and Candia, gave a depth of 300 feet beyond this. These single soundings, indeed, whether of ocean or sea, are always open to the certainty that greater as well as lesser depths must exist, to which no line has ever been sunk; a case coming under that general law of probabilities so largely applicable in every part of physics. In the Mediterranean especially, which has so many aspects of a sunken basin, there may be abysses of depth here and there which no plummet is ever destined to reach.—*Edinburgh Review.*

COLOUR OF THE RED SEA.

M. Ehrenberg, while navigating the Red Sea, observed that the red colour of its waters was owing to enormous quantities of a new animal, which has received the name of *oscillatoria rubescens*, and which seems to be the same with what Haller has described as a *purple conferva* swimming in water; yet Dr. Bonar, in his work entitled *The Desert of Sinai*, records:

> Blue I have called the sea; yet not strictly so, save in the far distance. It is neither a *red* nor a *blue* sea, but emphatically green,—yes, green, of the most brilliant kind I ever saw. This is produced by the immense tracts of shallow water, with yellow sand beneath, which always gives this green to the sea, even in the absence of verdure on the shore or sea-weeds beneath. The *blue* of the sky and the *yellow* of the sands meeting and intermingling in the water, form the *green* of the sea; the water being the medium in which the mixing or fusing of the colours takes place.

WHAT IS SEA-MILK?

The phenomena with this name and that of "Squid" are occasioned by the presence of phosphorescent animalcules. They are especially produced in the intertropical seas, and they appear to be chiefly abundant in the Gulf of Guinea and in the Arabian Gulf. In the latter, the phenomenon was known to the ancients more than a century before the Christian era, as may be seen from a curious passage from the geography of Agatharcides: "Along this country (the coast of Arabia) the sea has a white aspect like a river: the cause of this phenomenon is a subject of astonishment to us." M. Quatrefages has discovered that the *Noctilucæ* which produce this phenomenon do not always give out clear and brilliant sparks, but that under certain circumstances this light is replaced by a steady clearness, which gives in these animalcules a white colour. The waters in which they have been observed do not change their place to any sensible degree.

THE BOTTOM OF THE SEA A BURIAL-PLACE.

Among the minute shells which have been fished up from the great telegraphic plateau at the bottom of the sea between Newfoundland and Ireland, the microscope has failed to detect a single particle of sand or gravel; and the inference is, that there, if any where, the waters of the sea are at rest. There is not motion enough there to abrade these very delicate organisms, nor current enough to sweep them about and mix them up with a grain of the finest sand, nor the smallest particle of gravel from the loose beds of *débris* that here and there strew the bottom of the sea. The animalculæ probably do not live or die there. They would have had no light there; and, if they lived there, their frail textures would be subjected in their growth to a pressure upon them of a column of water 12,000 feet high, equal to the weight of 400 atmospheres. They probably live and sport near the surface, where they can feel the genial influence of both light and heat, and are buried in the lichen caves below after death.

It is now suggested, that henceforward we should view the surface of the sea as a nursery teeming with nascent organisms, and its depths as the cemetery for families of living creatures that outnumber the sands on the sea-shore for multitude.

Where there is a nursery, hard by there will be found also a graveyard,—such is the condition of the animal world. But it never occurred to us before to consider the surface of the sea as one wide nursery, its every ripple as a cradle, and its bottom one vast burial-place.—*Lieut. Maury.*

WHY IS THE SEA SALT?

It has been replied, In order to preserve it in a state of purity; which is, however, untenable, mainly from the fact that organic impurities in a vast body of moving water, whether fresh or salt, become rapidly lost, so as apparently to have called forth a special agency to arrest the total organised matter in its final oscillation between the organic and inorganic worlds. Thus countless hosts of microscopic creatures swarm in most waters, their principal function being, as Professor Owen surmises, to feed upon and thus restore to the living chain the almost unorganised matter of various zones. These creatures preying upon one another, and being preyed upon by others in their turn, the circulation of organic matter is kept up. If we do not adopt this view, we must at least look upon the Infusoria and Foraminifera as scavenger agents to prevent an undue accumulation of decaying matter; and thus the salt condition of the sea is not a necessity.

Nor is the amount of saline matter in the sea sufficient to arrest decomposition. That the sea is salt to render it of greater density, and by lowering its freezing point to preserve it from congelation to within a shorter distance of the poles, though admissible, scarcely meets the entire solution of the question. The freezing point of sea-water, for instance, is only 3½° F. lower than that of fresh water; hence, with the present distribution of land and sea—and still less, probably, with that which obtained in former geological epochs—no very important effects would have resulted had the ocean been fresh instead of salt.

Now Professor Chapman, of Toronto, suggests that the salt condition of the sea is mainly intended to regulate evaporation, and to prevent an undue excess of that phenomenon; saturated solutions evaporating more slowly than weak ones, and these latter more slowly again than pure water.

Here, then, we have a self-adjusting phenomenon and admirable contrivance in the balance of forces. If from any temporary cause there be an unusual amount of saline matter in the sea, evaporation goes on the more and more slowly; and, on the other hand, if this proportion be reduced by the addition of fresh water in undue excess, the evaporating power is the more and more increased—thus aiding time, in either instance, to restore the balance. The perfect system of oceanic circulation may be ascribed, in a great degree at least, if not wholly, to the effect produced by the salts of the sea upon the mobility and circulation of its waters.

Now this is an office which the sea performs in the economy of the universe by virtue of its saltness, and which it could not perform were its waters altogether fresh. And thus philosophers have a clue placed in their hands which will probably guide to one of the many hidden reasons that are embraced in the true answer to the question, "*Why is the sea salt?*"

HOW TO ASCERTAIN THE SALTNESS OF THE SEA.

Dry a towel in the sun, weigh it carefully, and note its weight. Then dip it into sea-water, wring it sufficiently to prevent its dripping, and weigh it again; the increase of the weight being that of the water imbibed by the cloth. It should then be thoroughly dried, and once more weighed; and the excess of this weight above the original weight of the cloth shows the quantity of the salt retained by it; then, by comparing the weight of this salt with that of the sea-water imbibed by the cloth, we shall find what proportion of salt was contained in the water.

ALL THE SALT IN THE SEA.

The amount of common Salt in all the oceans is estimated by Schafhäutl at 3,051,342 cubic geographical miles. This would be about five times more than the mass of the Alps, and only one-third less than that of the Himalaya. The sulphate of soda equals 633,644·36 cubic miles, or is equal to the mass of the Alps; the chloride of magnesium, 441,811·80 cubic miles; the lime salts, 109,339·44 cubic miles. The above supposes the mean depth to be but 300 metres, as estimated by Humboldt. Admitting, with Laplace, that the mean depth is 1000 metres, which is more probable, the mass of marine salt will be more than double the mass of the Himalaya.—*Silliman's Journal*, No. 16.

Taking the average depth of the ocean at two miles, and its average saltness at 3½ per cent, it appears that there is salt enough in the sea to cover to the thickness of one mile an area of 7,000,000 of square miles. Admit a transfer of such a quantity of matter from an average of half a mile above to one mile below the sea level, and astronomers will show by calculation that it would alter the length of the day.

These 7,000,000 of cubic miles of crystal salt have not made the sea any fuller.

PROPERTIES OF SEA-WATER.

The solid constituents of sea-water amount to about 3½ per cent of its weight, or nearly half an ounce to the pound. Its saltness is caused as follows: Rivers which are constantly flowing into the ocean contain salts varying from 10 to 50, and even 100, grains per gallon. They are chiefly common salt, sulphate and carbonate of lime, magnesia,* soda, potash, and iron; and these are found to constitute the distinguishing characteristics of sea-water. The water which evaporates from the sea is nearly pure, containing but very minute traces of salts. Falling as rain upon the land, it washes the soil, percolates through the rocky layers, and becomes charged with saline substances, which are borne seaward by the returning currents. The ocean, therefore, is the great depository of every thing that water can dissolve and carry down from the surface of the continents ; and as there is no channel for their escape, they consequently accumulate (*Youmans' Chemistry*). They would constantly accumulate, as this very shrewd author remarks, were it not for the shells and insects of the sea and other agents.

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* It is the chloride of magnesia which gives that damp sticky feeling to the clothes of sailors that are washed or wetted with salt-water.

SCENERY AND LIFE OF THE ARCTIC REGIONS.

The late Dr. Scoresby, from personal observations made in the course of twenty-one voyages to the Arctic Regions, thus describes these striking characteristics :

The coast scenes of Greenland are generally of an abrupt character, the mountains frequently rising in triangular profile ; so much so, that it is sometimes not possible to effect their ascent. One of the most notable characteristics of the Arctic lands is the deception to which travellers are liable in regard to distances. The occasion of this is the quantity of light reflected from the snow, contrasted with the dark colour of the rocks. Several persons of considerable experience have been deceived in this way, imagining, for example, that they were close to the shore when in fact they were more than twenty miles off. The trees of these lands are not more than three inches above ground.

Many of the icebergs are five miles in extent, and some are to be seen running along the shore measuring as much as thirteen miles. Dr. Scoresby has seen a cliff of ice supported on those floating masses 402 feet in height. There is no place in the world where animal life is to be found in greater profusion than in Greenland, Spitzbergen, Baffin's Bay, and other portions of the Arctic regions. This is to be accounted for by the abundance and richness of the food supplied by the sea. The number of birds is especially remarkable. On one occasion, no less than a million of little hawks came in sight of Dr. Scoresby's ship within a single hour.

The various phenomena of the Greenland sea are very interesting. The different colours of the sea-water—olive or bottle-green, reddish-brown, and mustard—have, by the aid of the microscope, been found to be owing to animalculæ of these various colours : in a single drop of mustard-coloured water have been counted 26,450 animals. Another remarkable characteristic of the Greenland sea-water is its warm temperature—one, two, and three degrees above the freezing-point even in the cold season. This Dr. Scoresby accounts for by supposing the flow in that direction of warm currents from the south. The polar fields of ice are to be found from eight or nine to thirty or forty feet in thickness. By fastening a hook twelve or twenty inches in these masses of ice, a ship could ride out in safety the heaviest gales.

ICEBERG OF THE POLAR SEAS.

The ice of this berg, although opaque and vascular, is true glacier ice, having the fracture, lustre, and other external characters of a nearly homogeneous growth. The iceberg is true ice, and is always dreaded by ships. Indeed, though modified by climate, and especially by the alternation of day and night, the polar glacier must be regarded as strictly atmospheric in its increments, and not essentially differing from the glacier of the Alps. The general appearance of a berg may be compared to frosted silver; but when its fractures are very extensive, the exposed faces have a very brilliant lustre. Nothing can be more exquisite than a fresh, cleanly fractured berg surface: it reminds one of the recent cleavage of sulphate of strontian—a resemblance more striking from the slightly lazulitic tinge of each.—*U.S. Grinnel Expedition in Search of Sir J. Franklin.*

IMMENSITY OF POLAR ICE.

The quantity of solid matter that is drifted out of the Polar Seas through one opening—Davis's Straits—alone, and during a part of the year only, covers to the depth of seven feet an area of 300,000 square miles, and weighs not less than 18,000,000,000 tons. The quantity of water required to float and drive out this solid matter is probably many times greater than this. A quantity of water equal in weight to these two masses has to go in. The basin to receive these inflowing waters, *i.e.* the unexplored basin about the North Pole, includes an area of 1,500,000 square miles; and as the outflowing ice and water are at the surface, the return current must be submarine.

These two currents, therefore, it may be perceived, keep in motion between the temperate and polar regions of the earth a volume of water, in comparison with which the mighty Mississippi in its greatest floods sinks down to a mere rill.—*Maury.*

OPEN SEA AT THE POLE.

The following fact is striking: In 1662-3, Mr. Oldenburg, Secretary to the Royal Society, was ordered to register a paper entitled "Several Inquiries concerning Greenland, answered by Mr. Gray, who had visited those parts." The nineteenth query was, "How near any one hath been known to approach the Pole. *Answer.* I once met upon the coast of Greenland a Hollander, that swore he had been but half a degree from the Pole, showing me his journal, which was also attested by his mate; where *they had seen no ice or land, but all water.*" Boyle mentions a similar account, which he received from an old Greenland master, on April 5, 1765.

RIVER-WATER ON THE OCEAN.

Captain Sabine found discoloured water, supposed to be that of the Amazon, 300 miles distant in the ocean from the embouchure of that river. It was about 126 feet deep. Its specific gravity was = 1·0204, and the specific gravity of the sea-water = 1·0262. This appears to be the greatest distance from land at which river-water has been detected on the surface of the ocean. It was estimated to be moving at the rate of three miles an hour, and had been turned aside by an ocean-current. "It is not a little curious to reflect," says Sir Henry de la Beche, "that the agitation and resistance of its particles should be sufficient to keep finely comminuted solid matter mechanically suspended, so that it would not be disposed freely to part with it except at its junction with the sea-water over which it flows, and where, from friction, it is sufficiently retarded."

THE THAMES AND ITS SALT-WATER BED.

The Thames below Woolwich, in place of flowing upon a solid bottom, really flows upon the liquid bottom formed by the water of the sea. At the flow of the tide, the fresh water is raised, as it were, in a single mass by the salt water which flows in, and which ascends the bed of the river, while the fresh water continues to flow towards the sea.—*Mr. Stevenson, in Jameson's Journal.*

FRESH SPRINGS IN THE MIDDLE OF THE OCEAN.

On the southern coast of the island of Cuba, at a few miles from land, Springs of Fresh Water gush from the bed of the Ocean, probably under the influence of hydrostatic pressure, and rise through the midst of the salt water. They issue forth with such force that boats are cautious in approaching this locality, which has an ill repute on account of the high cross sea thus caused. Trading vessels sometimes visit these springs to take in a supply of fresh water, which is thus obtained in the open sea. The greater the depth from which the water is taken, the fresher it is found to be.

"THE BLACK WATERS."

In the upper portion of the basin of the Orinoco and its tributaries, Nature has several times repeated the enigmatical phenomenon of the so-called "Black Waters." The Atabapo, whose banks are adorned with Carolinias and arborescent Melastomas, is a river of a coffee-brown colour. In the shade of the palm-groves this colour seems about to pass into ink-black. When placed in transparent vessels, the water appears of a golden yellow. The image of the Southern Constellation is reflected with wonderful clearness in these black streams. When their waters flow gently, they afford to the observer, when taking astronomical observations with reflecting instruments, a most excellent artificial horizon. These waters probably owe their peculiar colour to a solution of carburetted hydrogen, to the luxuriance of the tropical vegetation, and to the quantity of plants and herbs on the ground over which they flow.—*Humboldt's Aspects of Nature*, vol. i.

GREAT CATARACT IN INDIA.

Where the river Shirhawti, between Bombay and Cape Comorin, falls into the Gulf of Arabia, it is about one-fourth of a mile in width, and in the rainy season some thirty feet in depth. This immense body of water rushes down a rocky slope 300 feet, at an angle of 45°, at the bottom of which it makes a perpendicular plunge of 850 feet into a black and dismal abyss, with a noise like the loudest thunder. The whole descent is therefore 1150 feet, or several times that of Niagara; but the volume of water in the latter is somewhat larger than in the former.

CAUSE OF WAVES.

The friction of the wind combines with the tide in agitating the surface of the ocean, and, according to the theory of undulations, each produces its effect independently of the other. Wind, however, not only raises waves, but causes a transfer of superficial water also. Attraction between the particles of air and water, as well as the pressure of the atmosphere, brings its lower stratum into adhesive contact with the surface of the sea. If the motion of the wind be parallel to the surface, there will still be friction, but the water will be smooth as a mirror; but if it be inclined, in however small a degree, a ripple will appear. The friction raises a minute wave, whose elevation protects the water beyond it from the wind, which consequently impinges on the surface at a small angle: thus each impulse, combining with the other, produces an undulation which continually advances.—*Mrs. Somerville's Physical Geography.*

RATE AT WHICH WAVES TRAVEL.

Professor Bache states, as one of the effects of an earthquake at Simoda, on the island of Niphon, in Japan, that the harbour was first emptied of water, and then came in an enormous wave, which again receded and left the harbour dry. This occurred several times. The United-States self-acting tide-gauge at San Francisco, which records the rise of the tide upon cylinders turned by clocks, showed that at San Francisco, 4800 miles from the scene of the earthquake, the first wave arrived twelve hours and sixteen minutes after it had receded from the harbour of Simoda. It had travelled across the broad bosom of the Pacific Ocean at the rate of six miles and a half a minute, and arrived on the shores of California: the first wave being seven-tenths of a foot in height, and lasting for about half an hour, followed by seven lesser waves, at intervals of half an hour each.

The velocity with which a wave travels depends on the depth of the ocean. The latest calculations for the Pacific Ocean give a depth of from 14,000 to 18,000 fathoms. It is remarkable how the estimates of the ocean's depth have grown less. Laplace assumed it at ten miles, Whewell at 3·5, while the above estimate brings it down to two miles.

Mr. Findlay states, that the dynamic force exerted by Sea-Waves is greatest at the crest of the wave before it breaks; and its power in raising itself is measured by various facts. At Wasburg, in Norway, in 1820, it rose 400 feet; and on the coast of Cornwall, in 1843, 300 feet. The author shows that waves have sometimes raised a column of water equivalent to a pressure of from three to five tons the square foot. He also proves that the velocity of the waves depends on their length, and that waves of from 300 to 400 feet in length from crest to crest travel from twenty to twenty-seven and a half miles an hour. Waves travel great distances, and are often raised by distant hurricanes, having been felt simultaneously at St. Helena and Ascension, though 600 miles apart; and it is probable that ground-swells often originate at the Cape of Good Hope, 3000 miles distant. Dr. Scoresby found the travelling rate of the Atlantic waves to be 32·67 English statute miles per hour.

In the winter of 1856, a heavy ground-swell, brought on by five hours' gale, scoured away in fourteen hours 3,900,000 tons of pebbles from the coast near Dover; but in three days, without any shift of wind, upwards of 3,000,000 tons were thrown back again. These figures are to a certain extent conjectural; but the quantities have been derived from careful measurement of the profile of the beach.

OCEAN-HIGHWAYS: HOW SEA-ROUTES HAVE BEEN SHORTENED.

When one looks seaward from the shore, and sees a ship disappear in the horizon as she gains an offing on a voyage to India, or the Antipodes perhaps, the common idea is that she is bound over a trackless waste; and the chances of another ship sailing with the same destination the next day, or the next week, coming up and speaking with her on the "pathless ocean," would to most minds seem slender indeed. Yet the truth is, the winds and the currents are now becoming so well understood, that the navigator, like the backwoodsman in the wilderness, is enabled literally to "blaze his way" across the ocean; not, indeed, upon trees, as in the wilderness, but upon the wings of the wind. The results of scientific inquiry have so taught him how to use these invisible couriers, that they, with the calm belts of the air, serve as sign-boards to indicate to him the turnings and forks and crossings by the way.

Let a ship sail from New York to California, and the next week let a faster one follow; they will cross each other's path many times, and are almost sure to see each other by the way, as in the voyage of two fine clipper-ships from New York to California. On the ninth day after the *Archer* had sailed, the *Flying Cloud* put to sea. Both ships were running against time, but without reference to each other. Tho *Archer*, with wind and current charts in hand, went blazing her way across the calms of Cancer, and along the new route down through the north-east trades to the equator; the *Cloud* followed, crossing the equator upon the trail of Thomas of the *Archer*. Off Cape Horn she came up with him, spoke him, and handed him the latest New York dates. The *Flying Cloud* finally ranged ahead, made her adieus, and disappeared among the clouds that lowered upon the western horizon, being destined to reach her port a week or more in advance of her Cape Horn consort. Though sighting no land from the time of their separation until they gained tho offing of San Francisco,—some six or eight thousand miles off,—the tracks of the two vessels wero so nearly tho same, that being projected upon the chart, they appear almost as one.

This is the great courso of the ocean: it is 15,000 miles in length. Some of the most glorious trials of speed and of prowess that the world evor witnessed among ships that "walk the waters" havo taken place over it. Here the modern clipper-ship—the noblest work that has ever como from the hands of man—has been sent, guided by the lights of science, to contend with the elements, to outstrip steam, and astonish the world.—*Maury.*

ERROR UPON ERROR.

The great inducement to Mr. Babbage, some years since, to attempt the construction of a machine by which astronomical tables could be calculated and even printed by mechanical means, and with entire accuracy, was the errors in the requisite tables. Nineteen such errors, in point of fact, were discovered in an edition of Taylor's *Logarithms* printed in 1796; some of which might have led to the most dangerous results in calculating a ship's place. These nineteen errors (of which one only was an error of the press) were pointed out in the *Nautical Almanac* for 1832. In one of these *errata*, the seat of the error was stated to be in cosine of 14° 18′ 3″. Subsequent examination showed that there was an error of one second in this correction, and accordingly, in the *Nautical Almanac* of the next year a new correction was necessary. But in making the new correction of one second, a new error was committed of ten degrees, making it still necessary, in some future edition of the *Nautical Almanac*, to insert an *erratum* in an *erratum* of the *errata* in Taylor's *Logarithms*.—*Edinburgh Review*, vol. 59.

Phenomena of Heat.

THE LENGTH OF THE DAY AND THE HEAT OF THE EARTH.

As we may judge of the uniformity of temperature from the unaltered time of vibration of a pendulum, so we may also learn from the unaltered rotatory velocity of the earth the amount of stability in the mean temperature of our globe. This is the result of one of the most brilliant applications of the knowledge we had long possessed of the movement of the heavens to the thermic condition of our planet. The rotatory velocity of the earth depends on its volume; and since, by the gradual cooling of the mass by radiation, the axis of rotation would become shorter, the rotatory velocity would necessarily increase, and the length of the day diminish with a decrease of the temperature. From the comparison of the secular inequalities in the motions of the moon with the eclipses observed in former ages, it follows that, since the time of Hipparchus,—that is, for full 2000 years,—the length of the day has certainly not diminished by the hundredth part of a second. The decrease of the mean heat of the globe during a period of 2000 years has not therefore, taking the extremest limits, diminished as much as $\frac{1}{306}$th of a degree of Fahrenheit.*—*Humboldt's Cosmos*, vol. i.

NICE MEASUREMENT OF HEAT.

A delicate thermometer, placed on the ground, will be affected by the passage of a single cloud across a clear sky; and if a succession of clouds pass over, with intervals of clear sky between them, such an instrument has been observed to fluctuate accordingly, rising with each passing mass of vapour, and falling again when the radiation becomes unrestrained.

EXPENDITURE OF HEAT BY THE SUN.

Sir John Herschel estimates the total Expenditure of Heat by the Sun in a given time, by supposing a cylinder of ice 45 miles in diameter to be continually darted into the sun *with the velocity of light*, and that the water produced by its fusion were continually carried off: the heat now given off constantly by radiation would then be wholly expended in its liquefaction, on the one hand, so as to leave no radiant surplus; while, on the other, the actual temperature at its surface would undergo no diminution.

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* This fraction rests on the assumption that the dilatation of the substances of which the earth is composed is equal to that of glass, that is to say, $\frac{1}{18000}$ for 1°. Regarding this hypothesis, see Arago, in the *Annuaire* for 1834, pp. 177-190.

The great mystery, however, is to conceive how so enormous a conflagration (if such it be) can be kept up. Every discovery in chemical science here leaves us completely at a loss, or rather seems to remove further the prospect of probable explanation. If conjecture might be hazarded, we should look rather to the known possibility of an indefinite generation of heat by friction, or to its excitement by the electric discharge, than to any combustion of ponderable fuel, whether solid or gaseous, for the origin of the solar radiation.—*Outlines.*[*]

DISTINCTIONS OF HEAT.

Among the curious laws of modern science are those which regulate the transmission of radiant heat through transparent bodies. The heat of our fires is intercepted and detained by screens of glass, and, being so detained, warms them; while solar heat passes freely through and produces no such effect. "The more recent researches of Delaroche," says Sir John Herschel, "however, have shown that this detention is complete only when the temperature of the source of heat is low; but that as the temperature gets higher a portion of the heat radiated acquires a power of penetrating glass, and that the quantity which does so bears continually a larger and larger proportion to the whole, as the heat of the radiant body is more intense. This discovery is very important, as it establishes a community of nature between solar and terrestrial heat; while at the same time it leads us to regard the actual temperature of the sun as far exceeding that of any earthly flame."

LATENT HEAT.

This extraordinary principle exists in all bodies, and may be pressed out of them. The blacksmith hammers a nail until it becomes red hot, and from it he lights the match with which he kindles the fire of his forge. The iron has by this process become more dense, and percussion will not again produce incandescence until the bar has been exposed in fire to a red heat, when it absorbs heat, the particles are restored to their former state, and we can again by hammering develop both heat and light.—*R. Hunt, F.R.S.*

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[*] Electricity, traversing excessively rarefied air or vapours, gives out light, and doubtless also heat. May not a continual current of electric matter be constantly circulating in the sun's immediate neighbourhood, or traversing the planetary spaces, and exerting in the upper regions of its atmosphere those phenomena of which, on however diminutive a scale, we have yet an unequivocal manifestation in our Aurora Borealis?

HEAT AND EVAPORATION.

In a communication made to the French Academy, M. Daubrée calculates that the Evaporation of the Water on the surface of the globe employs a quantity of heat about equal to one-third of what is received from the sun; or, in other words, equal to the melting of a bed of ice nearly thirty-five feet in thickness if spread over the globe.

HEAT AND MECHANICAL POWER.

It has been found that Heat and Mechanical Power are mutually convertible; and that the relation between them is definite, 772 foot-pounds of motive power being equivalent to a unit of heat, that is, to the amount of heat requisite to raise a pound of water through one degree of Fahrenheit.

HEAT OF MINES.

One cause of the great Heat of many of our deep Mines, which appears to have been entirely lost sight of, is the chemical action going on upon large masses of pyritic matter in their vicinity. The heat, which is so oppressive in the United Mines in Cornwall that the miners work nearly naked, and bathe in water at 80° to cool themselves, is without doubt due to the decomposition of immense quantities of the sulphurets of iron and copper known to be in this condition at a short distance from these mineral works.—*R. Hunt, F.R.S.*

VIBRATION OF HEATED METALS.

Mr. Arthur Trevelyan discovered accidentally that a bar of iron, when heated and placed with one end on a solid block of lead, in cooling vibrates considerably, and produces sounds similar to those of an Æolian harp. The same effect is produced by bars of copper, zinc, brass, and bell-metal, when heated and placed on blocks of lead, tin, or pewter. The bars were four inches long, one inch and a half wide, and three-eighths of an inch thick.

The conditions essential to these experiments are, That two different metals must be employed—the one soft and possessed of moderate conducting powers, viz. lead or tin, the other hard; and it matters not whether soft metal be employed for the bar or block, provided the soft metal be cold and the hard metal heated.

That the surface of the block shall be uneven, for when rendered quite smooth the vibration does not take place; but the bar cannot be too smooth.

That no matter be interposed, else it will prevent vibration, with the exception of a burnish of gold leaf, the thickness of which cannot amount to the two-hundred-thousandth part of an inch.—*Transactions of the Royal Society of Edinburgh.*

EXPANSION OF SPIRITS.

Spirits expand and become lighter by means of heat in a greater proportion than water, wherefore they are heaviest in winter. A cubic inch of brandy has been found by many experiments to weigh ten grains more in winter than in summer, the difference being between four drams thirty-two grains and four drams forty-two grains. Liquor-merchants take advantage of this circumstance, and make their purchases in winter rather than in summer, because they get in reality rather a larger quantity in the same bulk, buying by measure.—*Notes in Various Sciences.*

HEAT PASSING THROUGH GLASS.

The following experiment is by Mr. Fox Talbot: Heat a poker bright-red hot, and having opened a window, apply the poker quickly very near to the outside of a pane, and the hand to the inside; a strong heat will be felt at the instant, which will cease as soon as the poker is withdrawn, and may be again renewed and made to cease as quickly as before. Now it is well known, that if a piece of glass is so much warmed as to convey the impression of heat to the hand, it will retain some part of that heat for a minute or more; but in this experiment the heat will vanish in a moment: it will not, therefore, be the heated pane of glass that we shall feel, but heat which has come through the glass in a free or radiant state.

HEAT FROM GAS-LIGHTING.

In the winter of 1835, Mr. W. H. White ascertained the temperature in the City to be 3° higher than three miles south of London Bridge; and *after the gas had been lighted in the City* four or five hours the temperature increased full 3°, thus making 6° difference in the three miles.

HEAT BY FRICTION.

Friction as a source of Heat is well known: we rub our hands to warm them, and we grease the axles of carriage-wheels to prevent their setting fire to the wood. Count Rumford has established the extraordinary fact, that an unlimited supply of heat may be derived from friction by the same materials: he made great quantities of water boil by causing a blunt borer to rub against a mass of metal immersed in the water. Savages light their fires by rubbing two pieces of wood: the *modus oper-*

andi, as practised by the Kaffirs of South Africa, is thus described by Captain Drayton:

> Two dry sticks, one being of hard and the other of soft wood, were the materials used. The soft stick was laid on the ground, and held firmly down by one Kaffir, whilst another employed himself in scooping out a little hole in the centre of it with the point of his assagy: into this little hollow the end of the hard wood was placed, and held vertically. These two men sat face to face, one taking the vertical stick between the palms of his hands, and making it twist about very quickly, while the other Kaffir held the lower stick firmly in its place; the friction caused by the end of one piece of wood revolving upon the other soon made the two pieces smoke. When the Kaffir who twisted became tired, the respective duties were exchanged. These operations having continued about a couple of minutes, sparks began to appear, and when they became numerous, were gathered into some dry grass, which was then swung round at arm's length until a blaze was established; and a roaring fire was gladdening the hearts of the Kaffirs with the anticipation of a glorious feast in about ten minutes from the time that the operation was first commenced.

HEAT BY FRICTION FROM ICE.

When Sir Humphry Davy was studying medicine at Penzance, one of his constant associates was Mr. Tom Harvey, a druggist in the above town. They constantly experimented together; and one severe winter's day, after a discussion on the nature of heat, the young philosophers were induced to go to Larigan river, where Davy succeeded in developing heat by *rubbing two pieces of ice together* so as to melt each other;* an experiment which he repeated with much *éclat* many years after, in the zenith of his celebrity, at the Royal Institution. The pieces of ice for this experiment are fastened to the ends of two sticks, and rubbed together in air below the temperature of 32°: this Davy readily accomplished on the day of severe cold at the Larigan river; but when the experiment was repeated at the Royal Institution, it was in the vacuum of an air-pump, when the temperature of the apparatus and of the surrounding air was below 32°. It was remarked, that when the surface of the rubbing pieces was rough, only half as much heat was evolved as when it was smooth. When the pressure of the rubbing piece was increased four times, the proportion of heat evolved was increased sevenfold.

WARMING WITH ICE.

In common language, any thing is understood to be cooled or warmed when the temperature thereof is made higher or lower, whatever may have been the temperature when the change was commenced. Thus it is said that melted iron is

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* Could we by mechanical pressure force water into a solid state, an immense quantity of heat would be set free.

cooled down to a sub-red heat, or mercury is cooled from the freezing point to zero, or far below. By the same rule, solid mercury, say 50° below zero, may, in any climate or temperature of the atmosphere, be immediately warmed and melted by being imbedded in a cake of ice.—*Scientific American.*

REPULSION BY HEAT.

If water is poured upon an iron sieve, the wires of which are made red-hot, it will not run through; but on cooling, it will pass through rapidly. M. Boutigny, pursuing this curious inquiry, has proved that the moisture upon the skin is sufficient to protect it from disorganisation if the arm is plunged into baths of melted metal. The resistance of the surfaces is so great that little elevation of temperature is experienced. Professor Plücker has stated, that by washing the arm with ether previously to plunging it into melted metal, the sensation produced while in the molten mass is that of freezing coldness.—*R. Hunt, F.R.S.*

PROTECTION FROM INTENSE HEAT.

The singular power which the body possesses of resisting great heats, and of breathing air of high temperatures, has at various times excited popular wonder. In the last century some curious experiments were made on this subject. Sir Joseph Banks, Dr. Solander, and Sir Charles Blagden, entered a room in which the air had a temperature of 198° Fahr., and remained ten minutes. Subsequently they entered the room separately, when Dr. Solander found the heat 210°, and Sir Joseph 211°, whilst their bodies preserved their natural degree of heat. Whenever they breathed upon a thermometer, it sank several degrees; every inspiration gave coolness to their nostrils, and their breath cooled their fingers when it reached them. Sir Charles Blagden entered an apartment when the heat was 1° or 2° above 260°, and remained eight minutes, mostly on the coolest spot, where the heat was above 240°. Though very hot, Sir Charles felt no pain: during seven minutes his breathing was good; but he then felt an oppression in his lungs, and his pulse was 144, double its ordinary quickness. To prove the heat of the room, eggs and a beefsteak were placed upon a tin frame near the thermometer, when in twenty minutes the eggs were roasted hard, and in forty-seven minutes the steak was dressed dry; and when the air was put in motion by a pair of bellows upon another steak, part of it was well done in thirteen minutes. It is remarkable, that in these experiments the same person who experienced no inconvenience from air heated to 211°, could just bear rectified spirits of wine at 130°, cooling oil at 129°, cooling water at 123°, and cooling quicksilver at 117°.

Sir Francis Chantrey, the sculptor, however, exposed himself to a temperature still higher than any yet mentioned, as described by Sir David Brewster:

> The furnace which he employs for drying his moulds is about fourteen feet long, twelve feet high, and twelve feet broad. When it is raised to its highest temperature, with the doors closed, the thermometer stands at 350°, and the iron floor is red-hot. The workmen often enter it at a temperature of 340°, walking over the iron floor with wooden clogs, which are of course charred on the surface. On one occasion, Mr. Chantrey, accompanied by five or six of his friends, entered the furnace; and after remaining two minutes they brought out a thermometer which stood at 320°. Some of the party experienced sharp pains in the tips of their ears and in the septum of the nose. while others felt a pain in their eyes.—*Natural Magic*, 1833.

In some cases the clothing worn by the experimenters conducts away the heat. Thus, in 1828, a Spaniard entered a heated oven, at the New Tivoli, near Paris; he sang a song while a fowl was roasted by his side, he then ate the fowl and drank a bottle of wine, and on coming out his pulse beat 176°, and the thermometer was at 110° Reaumur. He then stretched himself upon a plank in the oven surrounded by lighted candles, when the mouth of the oven was closed; he remained there five minutes, and on being taken out, all the candles were extinguished and melted, and the Spaniard's pulse beat 200°. Now much of the surprise ceases when it is added that he wore wide woollen pantaloons, a loose mantle of wool, and a great quilted cap; the several materials of this clothing being bad conductors of heat.

In 1829 M. Chabert, the "Fire-King," exhibited similar feats at the Argyll Rooms in Regent Street. He first swallowed forty grains of phosphorus, then two spoonfuls of oil at 330°, and next held his head over the fumes of sulphuric acid. He had previously provided himself with an antidote for the poison of the phosphorus. Dressed in a loose woollen coat, he then entered a heated oven, and in five minutes cooked two steaks; he then came out of the oven, when the thermometer stood at 380°. Upon another occasion, at White Conduit House, some of his feats were detected.

The scientific secret is as follows: Muscular tissue is an extremely bad conductor; and to this in a great measure the constancy of the temperature of the human body in various zones is to be attributed. To this fact also Sir Charles Blagden and Chantrey owed their safety in exposing their bodies to a high temperature; from the almost impervious character of the tissues of the body, the irritation produced was confined to the surface.

Magnetism and Electricity.

MAGNETIC HYPOTHESES.

As an instance of the obstacles which erroneous hypotheses throw in the way of scientific discovery, Professor Faraday adduces the unsuccessful attempts that had been made in England to educe Magnetism from Electricity until Oersted showed the simple way. Faraday relates, that when he came to the Royal Institution as an assistant in the laboratory, he saw Davy, Wollaston, and Young trying, by every way that suggested itself to them, to produce magnetic effects from an electric current; but having their minds diverted from the true course by their existing hypotheses, it did not occur to them to try the effect of holding a wire through which an electric current was passing over a suspended magnetic needle. Had they done so, as Oersted afterwards did, the immediate deflection of the needle would have proved the magnetic property of an electric current. Faraday has shown that the magnetism of a steel bar is caused by the accumulated action of all the particles of which it is composed: this he proves by first magnetising a small steel bar, and then breaking it successively into smaller and smaller pieces, each one of which possesses a separate pole; and the same operation may be continued until the particles become so small as not to be distinguishable without a microscope.

We quote the above from a late Number of the *Philosophical Magazine*, wherein also we find the following noble tribute to the genius and public and private worth of Faraday:

> The public never can know and appreciate the national value of such a man as Faraday. He does not work to please the public, nor to win ts guineas; and the said public, if asked its opinion as to the practical value of his researches, can see no possible practical issue there. The public does not know that we need prophets more than mechanics in cience,—inspired men, who, by patient self-denial and the exercise of he high intellectual gifts of the Creator, bring us intelligence of His oings in Nature. To them their pursuits are good in themselves. Their hief reward is the delight of being admitted into communion with Naure, the pleasure of tracing out and proclaiming her laws, wholly foretful whether those laws will ever augment our banker's account or mprove our knowledge of cookery. *Such men, though not honoured by e title of "practical," are they which make practical men possible.* They ring us the tamed forces of Nature, and leave it to others to contrive e machinery to which they may be yoked. If we are rightly informed, was Faradaic electricity which shot the glad tidings of the fall of Seastopol from Balaklava to Varna. Had this man converted his talent

to commercial purposes, as so many do, we should not like to set a limit to his professional income. The quality of his services cannot be expressed by pounds; but that brave body, which for forty years has been the instrument of that great soul, is a fit object for a nation's care, as the achievements of the man are, or will one day be, the object of a nation's pride and gratitude.

THE CHINESE AND THE MAGNETIC NEEDLE.

More than a thousand years before our era, a people living in the extremest eastern portions of Asia had magnetic carriages, on which the movable arm of the figure of a man continually pointed to the south, as a guide by which to find the way across the boundless grass-plains of Tartary; nay, even in the third century of our era, therefore at least 700 years before the use of the mariner's compass in European seas, Chinese vessels navigated the Indian Ocean under the direction of Magnetic Needles pointing to the south.

Now the Western nations, the Greeks and the Romans, knew that magnetism could be communicated to iron, and *that that metal* would retain it for a length of time. The great discovery of the terrestrial directive force depended, therefore, alone on this—that no one in the West had happened to observe an elongated fragment of magnetic ironstone, or a magnetic iron rod, floating by the aid of a piece of wood in water, or suspended in the air by a thread, in such a position as to admit of free motion.—*Humboldt's Cosmos*, vol. i.

KIRCHER'S "MAGNETISM."

More than two centuries since, Athanasius Kircher published his strange book on Magnetism, in which he anticipated the supposed virtue of magnetic traction in the curative art, and advocated the magnetism of the sun and moon, of the divining-rod, and showed his firm belief in animal magnetism. "In speaking of the vegetable world," says Mr. Hunt, "and the remarkable processes by which the leaf, the flower, and the fruit are produced, this sage brings forward the fact of the diamagnetic (repelled by the magnet) character of the plant which was in 1852 rediscovered; and he refers the motions of the sunflower, the closing of the convolvulus, and the directions of the spiral formed by the twining plants, to this particular influence."* Nor were Kircher's anticipations random guesses, but the result of deductions from experiment and observation; and the universality of magnetism is now almost recognised by philosophers.

MINUTE MEASUREMENT OF TIME.

By observing the magnet in the highly-convenient and delicate manner introduced by Gauss and Weber, which consists in attaching a mirror to the magnet and determining the constant factor necessary to convert the differences of oscillation into differences of time, Professor Helmholtz has been able, with comparatively simple apparatus, to make accurate determinations up to the $\frac{1}{10000}$th part of a second.

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* See Mr. Hunt's popular work, *The Poetry of Science; or, Studies of Physical Phenomena of Nature.* Third edition, revised and enlarged. Bohn, 1854.

POWER OF A MAGNET.

The Power of a Magnet is estimated by the weight its poles are able to carry. Each pole singly is able to support a smaller weight than when they both act together by means of a keeper, for which reason horse-shoe magnets are superior to bar magnets of similar dimensions and character. It has further been ascertained that small magnets have a much greater relative force than large ones.

When magnetism is excited in a piece of steel in the ordinary mode, by friction with a magnet, it would seem that its inductive power is able to overcome the coercive power of the steel only to a certain depth below the surface; hence we see why small pieces of steel, especially if not very hard, are able to carry greater relative weights than large magnets. Sir Isaac Newton wore in a ring a magnet weighing only 3 grains, which would lift 760 grains, *i. e.* 250 times its own weight.

Bar-magnets are seldom found capable of carrying more than their own weight; but horse-shoe magnets of similar steel will bear considerably more. Small ones of from half an ounce to 1 ounce in weight will carry from 30 to 40 times their own weight; while such as weigh from 1 to 2 lbs. will rarely carry more than from 10 to 15 times their weight. The writer found a 1 lb. horse-shoe magnet that he impregnated by means of the feeder able to bear 26½ times its own weight; and Fischer, having adopted the like mode of magnetising the steel, which he also carefully heated, has made magnets of from 1 to 3 lbs. weight that would carry 30 times, and others of from 4 to 6 lbs. weight that would carry 20 times, their own weight.—*Professor Peschel.*

HOW ARTIFICIAL MAGNETS ARE MADE.

In 1750, Mr. Canton, F.R.S., "one of the most successful experimenters in the golden age of electricity,"* communicated to the Royal Society his "Method of making Artificial Magnets without the use of natural ones." This he effected by using a poker and tongs to communicate magnetism to steel bars. He derived his first hint from observing them one evening, as he was sitting by the fire, to be nearly in the same direction with the earth as the dipping needle. He thence concluded that they must, from their position and the frequent blows they receive, have acquired some magnetic virtue, which on trial he found to be the case; and therefore he employed them to impregnate his bars, instead of having recourse to the natural loadstone. Upon the reading of the above paper, Canton exhibited to the Royal Society his experiments, for which the Copley Medal was awarded to him in 1751.

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* Canton was the first who in England verified Dr. Franklin's idea of the similarity of lightning and the electric fluid, July 1752.

Canton had, as early as 1747, turned his attention, with complete success, to the production of powerful artificial magnets, principally in consequence of the expense of procuring those made by Dr. Gowan Knight, who kept his process secret. Canton for several years abstained from communicating his method even to his most intimate friends, lest it might be injurious to Dr. Knight, who procured considerable pecuniary advantages by touching needles for the mariner's compass.

At length Dr. Knight's method of making artificial magnets was communicated to the world by Mr. Wilson, in a paper published in the 69th volume of the *Philosophical Transactions.* He provided himself with a large quantity of clean iron-filings, which he put into a capacious tub about half full of clear water; he then agitated the tub to and fro for several hours, until the filings were reduced by attrition to an almost impalpable powder. This powder was then dried, and formed into paste by admixture with linseed-oil. The paste was then moulded into convenient shapes, which were exposed to a moderate heat until they had attained a sufficient degree of hardness.

After allowing them to remain for some time in this state, Dr. Knight gave them their magnetic virtue in any direction he pleased, by placing them between the extreme ends of his large magazine of artificial magnets for a second or more, as he saw occasion. By this method the virtue they acquired was such, that when any one of these pieces was held between two of his best ten-guinea bars, with its poles purposely inverted, it immediately of itself turned about to recover its natural direction, which the force of those very powerful bars was not sufficient to counteract.

Dr. Knight's powerful battery of magnets above mentioned is in the possession of the Royal Society, having been presented by Dr. John Fothergill in 1776.

POWER OF THE SUN'S RAYS IN INCREASING THE STRENGTH OF MAGNETS.

Professor Barlocci found that an armed natural loadstone, which would carry 1½ Roman pounds, had its power nearly *doubled* by twenty-four hours' exposure to the strong light of the sun. M. Zantedeschi found that an artificial horse-shoe loadstone, which carried 13½ oz., carried 3½ more by three days' exposure, and at last arrived to 31 oz. by continuing it in the sun's light. He found that while the strength increased in oxidated magnets, it diminished in those which were not oxidated, the diminution becoming insensible when the loadstone was highly polished. He now concentrated the solar rays upon the loadstone by means of a lens; and he found that, both in oxidated and polished magnets, they *acquire* strength when their *north* pole is exposed to the sun's rays, and *lose* strength when the *south* pole is exposed.—*Sir David Brewster.*

COLOUR OF A BODY AND ITS MAGNETIC PROPERTIES.

Solar rays bleach dead vegetable matter with rapidity, while in living parts of plants their action is frequently to strengthen the colour. Their power is perhaps best seen on the sides of peaches, apples, &c., which, exposed to a midsummer's sun, become highly coloured. In the open winter of 1850, Mr. Adie, of Liverpool, found in a wallflower plant proof of a like effect: in the dark months there was a slow succession of one or two flowers, of uniform pale yellow hue; in March streaks of a darker colour appeared on the flowers, and continued to slowly increase till in April they were variegated brown and yellow, of rich strong colours. On the supposition that these changes are referable to magnetic properties, may hereafter be explained Mrs. Somerville's experiments on steel needles exposed to the sun's rays under envelopes of silk of various colours; the magnetisation of steel needles has failed in the coloured rays of the spectrum, but Mr. Adie considers that under dyed silk the effect will hinge on the chemical change wrought in the silk and its dye by the solar rays.

THE ONION AND MAGNETISM.

A popular notion has long been current, more especially on the shores of the Mediterranean, that if a magnetic rod be rubbed with an onion, or brought in contact with the emanations of the plant, the directive force will be diminished, while a compass thus treated will mislead the steersman. It is difficult to conceive what could have given rise to so singular a popular error.*—*Humboldt's Cosmos*, vol. v.

DECLINATION OF THE NEEDLE—THE EARTH A MAGNET.

The Inclination or Dip of the Needle was first recorded by Robert Norman, in a scarce book published in 1576 entitled *The New Attractive; containing a short Discourse of the Magnet or Loadstone, &c.*

Columbus has not only the merit of being the first to discover *a line without magnetic variation*, but also of having first excited a taste for the study of terrestrial magnetism in Europe, by means of his observations on the progressive increase of western declination in receding from that line.

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* This is mentioned in *Procli Diadochi Paraphrasis Ptolem.*, 1635. (Delambre, *Hist. de l'Astronomie ancienne.*)

The first chart showing the variation of the compass,* or the declination of the needle, based on the idea of employing curves drawn through points of equal declination, is due to Halley, who is justly entitled the father and founder of terrestrial magnetism. And it is curious to find that in No. 195 of the *Philosophical Transactions*, in 1683, Halley had previously expressed his belief that he has put it past doubt that the globe of the earth is one great magnet, having four magnetical poles or points of attraction, near each pole of the equator two; and that in those parts of the world which lie near adjacent to any one of those magnetical poles, the needle is chiefly governed thereby, the nearest pole being always predominant over the more remote.

"To Halley" (says Sir John Herschel) "we owe the first appreciation of the real complexity of the subject of magnetism. It is wonderful indeed, and a striking proof of the penetration and sagacity of this extraordinary man, that with his means of information he should have been able to draw such conclusions, and to take so large and comprehensive a view of the subject as he appears to have done."

And, in our time, "the earth is a great magnet," says Faraday: "its power, according to Gauss, being equal to that which would be conferred if every cubic yard of it contained six one-pound magnets; the sum of the force is therefore equal to 8,464,000,000,000,000,000,000 such magnets."

THE AURORA BOREALIS.

Halley, upon his return from his voyage to verify his theory of the variation of the compass, in 1700, hazarded the conjecture that the Aurora Borealis is a magnetic phenomenon. And Faraday's brilliant discovery of the evolution of light by magnetism has raised Halley's hypothesis, enounced in 1714, to the rank of an experimental certainty.

EFFECT OF LIGHT ON THE MAGNET.

In 1854, Sir John Ross stated to the British Association, in proof of the effect of every description of light on the magnet, that during his last voyage in the *Felix*, when frozen in about one hundred miles north of the magnetic pole, he concentrated the rays of the full moon on the magnetic needle, when he found it was five degrees attracted by it.

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* The first Variation-Compass was constructed, before 1525, by an ingenious apothecary of Seville, Felisse Guillen. So earnest were the endeavours to learn more exactly the direction of the curves of magnetic declination, that in 1585 Juan Jayme sailed with Francisco Gali from Manilla to Acapulco, for the sole purpose of trying in the Pacific a declination instrument which he had invented.—*Humboldt.*

MAGNETO-ELECTRICITY.

In 1820, the Copley Medal was adjudicated to M. Oersted of Copenhagen, "when," says Dr. Whewell, "the philosopher announced that the conducting-wire of a voltaic circuit acts upon a magnetic needle; and thus recalled into activity that endeavour to connect magnetism with electricity which, though apparently on many accounts so hopeful, had hitherto been attended with no success. Oersted found that the needle has a tendency to place itself at *right angles* to the wire; a kind of action altogether different from any which had been suspected."

ELECTRO-MAGNETS OF THE HORSE-SHOE FORM

were discovered by Sturgeon in 1825. Of two Magnets made by a process devised by M. Elias, and manufactured by M. Logemeur at Haerlem, one, a single horse-shoe magnet weighing about 1 lb., lifts 28½ lbs.; the other, a triple horse-shoe magnet of about 10 lbs. weight, is capable of lifting about 150 lbs. Similar magnets are made by the same person capable of supporting 5 cwt. In the process of making them, a helix of copper and a galvanic battery are used. The smaller magnet has twice the power expressed by Haecker's formula for the best artificial steel magnet.

Subsequently Henry and Ten Eyk, in America, constructed some electro-magnets on a large scale. One horse-shoe magnet made by them, weighing 60 lbs., would support more than 2000 lbs.

In September 1858, there were constructed for the Atlantic-telegraph cable at Valentia two permanent magnets, from which the electric induction is obtained: each is composed of 30 horse-shoe magnets, 2½ feet long and from 4 to 5 inches broad; the induction coils attached to these each contain six miles of wire, and a shock from them, if passed through the human body, would be sufficient to destroy life.

ROTATION-MAGNETISM.

The unexpected discovery of Rotation-Magnetism by Arago, in 1825, has shown practically that every kind of matter is susceptible of magnetism; and the recent investigations of Faraday on diamagnetic substances have, under special conditions of meridian or equatorial direction, and of solid, fluid, or gaseous inactive conditions of the bodies, confirmed this important result.

INFLUENCE OF PENDULUMS ON EACH OTHER.

About a century since it became known, that when two clocks are in action upon the same shelf, they will disturb each other: that the pendulum of the one will stop that of the other; and that the pendulum that was stopped will after a while resume its vibrations, and in its turn stop that of the other clock. When two clocks are placed near one another in cases very slightly fixed, or when they stand on the boards of a floor, they will affect a little each other's pendulum. Mr. Ellicote observed that two clocks resting against the same rail, which agreed to a second for several days, varied one minute thirty-six seconds in twenty-four hours when separated. The slower, having a longer pendulum, set the other in motion in 16⅓ minutes, and stopped itself in 36⅔ minutes.

WEIGHT OF THE EARTH ASCERTAINED BY THE PENDULUM.

By a series of comparisons with Pendulums placed at the surface and the interior of the Earth, the Astronomer-Royal has ascertained the variation of gravity in descending to the bottom of a deep mine, as the Harton coal-pit, near South Shields. By calculations from these experiments, he has found the mean density of the earth to be 6·566, the specific gravity of water being represented by unity. In other words, it has been ascertained by these experiments that if the earth's mass possessed every where its average density, it would weigh, bulk for bulk, 6·566 times as much as water. It is curious to note the different values of the earth's mean density which have been obtained by different methods. The Schehallien experiment indicated a mean density equal to about 4½; the Cavendish apparatus, repeated by Baily and Reich, about 5½; and Professor Airy's pendulum experiment furnishes a value amounting to about 6½.

The immediate result of the computations of the Astronomer-Royal is: supposing a clock adjusted to go true time at the top of the mine, it would gain 2¼ seconds per day at the bottom. Or it may be stated thus: that gravity is greater at the bottom of a mine than at the top by $\frac{1}{19190}$th part.—*Letter to James Mather, Esq., South Shields.* See also *Professor Airy's Lecture*, 1854.

ORIGIN OF TERRESTRIAL MAGNETISM.

The earliest view of Terrestrial Magnetism supposed the existence of a magnet at the earth's centre. As this does not accord with the observations on declination, inclination, and intensity, Tobias Meyer gave this fictitious magnet an eccentric position, placing it one-seventh part of the earth's radius from the centre. Hansteen imagined that there were two such magnets, different in position and intensity. Ampère set aside these unsatisfactory hypotheses by the view, derived from his discovery, that the earth itself is an electro-magnet, magnetised by an electric current circulating about it from east to west perpendicularly to the plane of the magnetic meridian, to which the same currents give direction as well as magnetise the ores of iron : the currents being thermo-electric currents, excited by the action of the sun's heat successively on the different parts of the earth's surface as it revolves towards the east.

William Gilbert,* who wrote an able work on magnetic and electric forces in the year 1600, regarded terrestrial magnetism and electricity as two emanations of a single fundamental source pervading all matter, and he therefore treated of both at once. According to Gilbert's idea, the earth itself is a magnet; whilst he considered that the inflections of the lines of equal declination and inclination depend upon the distribution of mass, the configuration of continents, or the form and extent of the deep intervening oceanic basins.

Till within the last eighty years, it appears to have been the received opinion that the intensity of terrestrial magnetism was the same at all parts of the earth's surface. In the instructions drawn up by the French Academy for the expedition under La Pérouse, the first intimation is given of a contrary opinion. It is recommended that the time of vibration of a dipping-needle should be observed at stations widely remote, as a test of the equality or difference of the magnetic intensity; suggesting also that such observations should particularly be made at those parts of the earth where the dip was greatest and where it was least. The experiments, whatever their results may have been, which, in compliance with this recommendation, were made in the expedition of La Pérouse, perished in its general catastrophe; but the instructions survived.

In 1811, Hansteen took up the subject, and in 1819 published his celebrated work, clearly demonstrating the fluctuations which this element has undergone during the last two centuries; confirming in great detail the position of Halley, that "the whole magnetic system is in motion, that the moving force is very great as extending its effects from pole to pole, and that its motion is not *per saltum*, but a gradual and regular motion."

THE NORTH AND SOUTH MAGNETIC POLES.

The knowledge of the geographical position of both Magnetic Poles is due to the scientific energy of the same navigator, Sir James Ross. His observations of the Northern Magnetic Pole were made during the second expedition of his uncle, Sir John Ross (1829-1833); and of the Southern during the Antarctic expedition under his own command (1839-1843). The Northern Magnetic Pole, in 70° 5′ lat., 96° 43′ W. long., is 5° of latitude farther from the ordinary pole of the earth than the Southern Magnetic Pole, 75° 35′ lat., 154° 10′ E. long.; whilst it is also situated farther west from Greenwich than the Northern Magnetic Pole. The latter belongs to the great island of Boothia Felix, which is situated very near the American continent, and is a portion of the district which Captain Parry had previously named North Somerset. It is not far distant from the western coast of Boothia Felix, near the promontory of Adelaide, which extends into King William's Sound and Victoria Strait.

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* Gilbert was surgeon to Queen Elizabeth and James I., and died in 1603. Whewell justly assigns him an important place among the "practical reformers of the physical sciences." He adopted the Copernican doctrine, which Lord Bacon's inferior aptitude for physical research led him to reject.

The Southern Magnetic Pole has been directly reached in the same manner as the Northern Pole. On 17th February 1841, the *Erebus* penetrated as far as 76° 12′ S. lat., and 164° E. long. As the inclination was here only 88° 40′, it was assumed that the Southern Magnetic Pole was about 160 nautical miles distant. Many accurate observations of declination, determining the intersection of the magnetic meridian, render it very probable that the South Magnetic Pole is situated in the interior of the great Antarctic region of South Victoria Land, west of the Prince Albert mountains, which approach the South Pole and are connected with the active volcano of Erebus, which is 12,400 feet in height.—*Humboldt's Cosmos*, vol. v.

MAGNETIC STORMS.

The mysterious course of the magnetic needle is equally affected by time and space, by the sun's course, and by changes of place on the earth's surface. Between the tropics the hour of the day may be known by the direction of the needle as well as by the oscillations of the barometer. It is affected instantly, but transiently, by the northern light.

When the uniform horary motion of the needle is disturbed by a magnetic storm, the perturbation manifests itself *simultaneously*, in the strictest sense of the word, over hundreds and thousands of miles of sea and land, or propagates itself by degrees in short intervals every where over the earth's surface.

Among numerous examples of perturbations occurring simultaneously and extending over wide portions of the earth's surface, one of the most remarkable is that of September 25th, 1841, which was observed at Toronto in Canada, at the Cape of Good Hope, at Prague, and partially in Van Diemen's Land. Sabine adds, "The English Sunday, on which it is deemed sinful, after midnight on Saturday, to register an observation, and to follow out the great phenomena of creation in their perfect development, interrupted the observation in Van Diemen's Land, where, in consequence of the difference of the longitude, the magnetic storm fell on Sunday."

It is but justice to add, that to the direct instrumentality of the British Association we are indebted for this system of observation, which would not have been possible without some such machinery for concerted action. It being known that the magnetic needle is subject to oscillations, the nature, the periods, and the laws of which were unascertained, under the direction of a committee of the Association *magnetic observatories* were established in various places for investigating these strange disturbances. As might have been anticipated, regularly recurring perturbations were noted, depending on the hour of the day and the season of the year. Magnetic storms were observed to sweep simultaneously over the whole face of the earth, and these too have now been ascertained to follow certain periodic laws.

But the most startling result of the combined magnetic observations is the discovery of marked perturbations recurring at intervals of ten years; a period which seemed to have no analogy to any thing in the universe, but which M. Schwabe has found to correspond with the variation of the spots on the sun, both attaining their maximum and minimum developments at the same time. Here, for the present, the discovery stops; but that which is now an unexplained coincidence may hereafter supply the key to the nature and source of Terrestrial Magnetism: or, as Dr. Lloyd observes, this system of magnetic observation has gone beyond our globe, and opened a new range for inquiry, by showing us that this wondrous agent has power in other parts of the solar system.

FAMILIAR GALVANIC EFFECTS.

By means of the galvanic agency a variety of surprising effects have been produced. Gunpowder, cotton, and other inflammable substances have been set on fire; charcoal has been made to burn with a brilliant white flame; water has been decomposed into its elementary parts; metals have been melted and set on fire; fragments of diamond, charcoal, and plumbago have been dispersed as if evaporated; platina, the hardest and the heaviest of the metals, has been melted as readily as wax in the flame of a candle; the sapphire, quartz, magnesia, lime, and the firmest compounds in nature, have been fused. Its effects on the animal system are no less surprising.

The agency of galvanism explains why porter has a different and more pleasant taste when drunk out of a pewter-pot than out of glass or earthenware; why works of metal which are soldered together soon tarnish in the place where the metals are joined; and why the copper sheathing of ships, when fastened with iron nails, is soon corroded about the place of contact. In all these cases a galvanic circle is formed which produces the effects.

THE SIAMESE TWINS GALVANISED

It will be recollected that the Siamese twins, brought to

England in the year 1829, were united by a jointed cartilaginous band. A silver tea-spoon being placed on the tongue of one of the twins and a disc of zinc on the tongue of the other, the moment the two metals were brought into contact both the boys exclaimed, "Sour, sour;" thus proving that the galvanic influence passed from the one to the other through the connecting band.

MINUTE AND VAST BATTERIES.

Dr. Wollaston made a simple apparatus out of a silver thimble, with its top cut off. It was then partially flattened, and a small plate of zinc being introduced into it, the apparatus was immersed in a weak solution of sulphuric acid. With this minute battery, Dr. Wollaston was able to fuse a wire of platinum $\frac{1}{3000}$th of an inch in diameter—a degree of tenuity to which no one had ever succeeded in drawing it.

Upon the same principle (that of introducing a plate of zinc between two plates of other metals) Mr. Children constructed his immense battery, the zinc plates of which measured six feet by two feet eight inches; each plate of zinc being placed between two of copper, and each triad of plates being enclosed in a separate cell. With this powerful apparatus a wire of platinum, $\frac{1}{10}$th of an inch in diameter and upwards of five feet long, was raised to a red heat, visible even in the broad glare of daylight.

The great battery at the Royal Institution, with which Sir Humphry Davy discovered the composition of the fixed alkalies, was of immense power. It consisted of 200 separate parts, each composed of ten double plates, and each plate containing thirty-two square inches; the number of double plates being 2000, and the whole surface 128,000 square inches.

Mr. Highton, C.E., has made a battery which exposes a surface of only $\frac{1}{100}$th part of an inch: it consists of but one cell; it is less than $\frac{1}{10000}$th part of a cubic inch, and yet it produces electricity more than enough to overcome all the resistance in the inventor's brother's patent Gold-leaf Telegraph, and works the same powerfully. It is, in short, a battery which, although *it will go through the eye of a needle*, will yet work a telegraph well. Mr. Highton had previously constructed a battery in size less than $\frac{1}{40}$th of a cubic inch: this battery, he found, would for a month together ring a telegraph-bell ten miles off.

ELECTRIC INCANDESCENCE OF CHARCOAL POINTS.

The most splendid phenomenon of this kind is the combustion of charcoal points. Pointed pieces of the residuum obtained from gas retorts will answer best, or Bunsen's composition may be used for this purpose. Put two such charcoal points in immediate contact with the wires of your battery; bring the points together, and they will begin to burn with a dazzling white light. The charcoal points of the large apparatus belonging to the Royal Institution became incandescent at a distance of $\frac{1}{30}$th of an inch; when the distance was gradually increased till they were four inches asunder, they continued to burn with great intensity, and a permanent stream of light played between them. Professor Bunsen obtained a similar flame from a battery of four pairs of plates, its carbon surface containing 29 feet. The heat of this flame is so intense, that stout platinum wire, sapphire, quartz, talc, and lime are reduced by it to the liquid form. It is worthy of remark, that no combustion, properly so called, takes place in the charcoal itself; which sustains only an extremely minute loss in its weight and becomes rather denser at the points. The phenomenon is attended with a still more vivid brightness if the charcoal points are placed in a vacuum, or in any of those gases which are not supporters of combustion. Instead of two charcoal points, one only need be used if the following arrangement is adopted: lay the piece of charcoal on some quicksilver that is connected with one pole of the battery, and complete the circuit from the other pole by means of a strip of platinum. When Professor Peschel used a piece of well-burnt coke in the manner just described, he obtained a light which was almost intolerable to the eyes.

VOLTAIC ELECTRICITY.

On January 31, 1793, Volta announced to the Royal Society his discovery of the development of electricity in metallic bodies. Galvani had given the name of Animal Electricity to the power which caused spontaneous convulsions in the limbs of frogs when the divided nerves were connected by a metallic wire. Volta, however, saw the true cause of the phenomena described by Galvani. Observing that the effects were far greater when the connecting medium consisted of two different kinds of metal, he inferred that the principle of excitation existed in the metals, and not in the nerves of the animal; and he assumed that the exciting fluid was ordinary electricity, produced by the contact of the two metals; the convulsions of the frog consequently arose from the electricity thus developed passing along its nerves and muscles.

In 1800 Volta invented what is now called the Voltaic Pile, or compound Galvanic circle.

The term Animal Electricity (says Dr. Whewell) has been superseded by others, of which *Galvanism* is the most familiar; but I think that Volta's office in this discovery is of a much higher and more philosophical kind than that of Galvani; and it would on this account be more fitting to employ the term *Voltaic Electricity,* which, indeed, is very commonly used, especially by our most recent and comprehensive writers. The *Voltaic pile* was a more important step in the history of electricity than the Leyden jar had been.—*Hist. Ind. Sciences,* vol. iii.

No one who wishes to judge impartially of the scientific history of these times and of its leaders, will consider Galvani and Volta as equals, or deny the vast superiority of the latter over all his opponents or fellow-workers, more especially over those of the Bologna school. We shall scarcely again find in one man gifts so rich and so calculated for research as were combined in Volta. He possessed that "incomprehensible talent," as Dove has called it, for separating the essential from the immaterial in complicated phenomena; that boldness of invention which must precede experiment, controlled by the most strict and cautious mode of manipulation; that unremitting attention which allows no circumstance to pass unnoticed; lastly, with so much acuteness, so much simplicity, so much grandeur of conception, combined with such depth of thought, he had a hand which was the hand of a workman.—*Jameson's Journal,* No. 106.

THE VOLTAIC BATTERY AND THE GYMNOTUS.

"We boast of our Voltaic Batteries," says Mr. Smee. "I should hardly be believed if I were to say that I did not feel pride in having constructed my own, especially when I consider the extensive operations which it has conducted. But when I compare my battery with the battery which nature has given to the electrical eel and the torpedo, how insignificant are human operations compared with those of the Architect of living beings! The stupendous electric eel in the Polytechnic Institution, when he seeks to kill his prey, encloses him in a circle; then, by volition, causes the voltaic force to be produced, and the hapless creature is instantly killed. It would probably require ten thousand of my artificial batteries to effect the same object, as the creature is killed *instanter* on receiving the shock. As much, however, as my battery is inferior to that of the electric fish, so is man superior to the same animal. Man is endowed with a power of mind competent to appreciate the force of matter, and is thus enabled to make the battery. The eel can but use the specific apparatus which nature has bestowed upon it."

Some observations upon the electric current around the gymnotus, and notes of experiments with this and other electric fish, will be found in *Things not generally Known,* p. 199.

VOLTAIC CURRENTS IN MINES.

Many years ago, Mr. R. W. Fox, from theory entertaining a belief that a connection existed between voltaic action in the interior of the earth and the arrangement of metalliferous veins, and also the progressive increase of temperature in the strata as we descend from the surface, endeavoured to verify the same from experiment in the mine of Huel Jewel, in Cornwall. His apparatus consisted of small plates of sheet-copper, which were fixed in contact with a plate in the veins with copper nails, or else wedged closely against them with wooden props stretched across the galleries. Between two of these plates, at different stations, a communication was made by means of a copper wire $\frac{1}{20}$th of an inch in diameter, which included a galvanometer in its circuit. In some instances 300 fathoms of copper wire were employed. It was then found that the intensity of the voltaic current was generally greater in proportion to the greater abundance of copper ore in the veins, and in some degree to the depth of the stations. Hence Mr. Fox's discovery promised to be of practical utility to the miner in discovering the relative quantity of ore in the veins, and the directions in which it most abounds.

The result of extended experiments, mostly made by Mr. Robert Hunt, has not, however, confirmed Mr. Fox's views. It has been found that the voltaic currents detected in the lodes are due to the chemical decomposition going on there; and the more completely this process of decomposition is established, the more powerful are the voltaic currents. Meanwhile these have nothing whatever to do with the increase of temperature with depth. Recent observations, made in the deep mines of Cornwall under the direction of Mr. Fox, do not appear consistent with the law of thermic increase as formerly established, the shallow mines giving a higher ratio of increase than the deeper ones.

GERMS OF ELECTRIC KNOWLEDGE.

Two centuries and a half ago, Gilbert recognised that the property of attracting light substances when rubbed, be their nature what it may, is not peculiar to amber, which is a condensed earthy juice cast up by the waves of the sea, and in which flying insects, ants, and worms lie entombed as in eternal sepulchres. The force of attraction (Gilbert continues) belongs to a whole class of very different substances, as glass, sulphur, sealing-wax, and all resinous substances—rock crystal and all precious stones, alum and rock-salt. Gilbert measured the strength of the excited electricity by means of a small needle—not made of iron—which moved freely on a pivot, and perfectly similar to the apparatus used by Haüy and Brewster in testing the electricity excited in minerals by heat and friction. "Friction," says Gilbert further, "is productive of a stronger effect in dry than in humid air; and rubbing with silk cloths is most advantageous."

Otto von Guerike, the inventor of the air-pump, was the first who observed any thing more than mere phenomena of attraction. In his experiments with a rubbed piece of sulphur he recognised the phenomena of repulsion, which subsequently led to the establishment of the laws of the sphere of action and of the distribution of electricity. *He heard the first sound, and saw the first light, in artificially-produced electricity.* In an experiment instituted by Newton in 1675, the first traces of an electric charge in a rubbed plate of glass were seen.

TEMPERATURE AND ELECTRICITY.

Professor Tyndall has shown that all variations of temperature, in metals at least, excite electricity. When the wires of a galvanometer are brought in contact with the two ends of a heated poker, the prompt deflection of the galvanometer-needle indicates that a current of electricity has been sent through the instrument. Even the two ends of a spoon, one of which has been dipped in hot water, serve to develop an electric current; and in cutting a hot beefsteak with a steel knife and a silver fork there is an excitement of electricity. The mere heat of the finger is sufficient to cause the deflection of the galvanometer; and when ice is applied to the part that has been previously warmed, the galvanometer-needle is deflected in the contrary direction. A small instrument invented by Melloni is so extremely sensitive of the action of heat, that electricity is excited when the hand is held six inches from it.

VAST ARRANGEMENT OF ELECTRICITY.

Professor Faraday has shown that the Electricity which decomposes, and that which is evolved in the decomposition of, a certain quantity of matter, are alike. What an enormous quantity of electricity, therefore, is required for the decomposition of a single grain of water! It must be in quantity sufficient to sustain a platinum wire $\frac{1}{104}$th of an inch in thickness red-hot in contact with the air for three minutes and three-quarters. It would appear that 800,000 charges of a Leyden battery, charged by thirty turns of a very large and powerful plate-machine in full action, are necessary to supply electricity sufficient to decompose a single grain of water, or to equal the quantity of electricity which is naturally associated with the elements of that grain of water, endowing them with their mutual chemical affinity. Now the above quantity of electricity, if passed at once through the head of a rat or a cat, would kill it as by a flash of lightning. The quantity is, indeed, equal to that which is developed from a charged thunder-cloud.

DECOMPOSITION OF WATER BY ELECTRICITY.

Professor Andrews, by an ingenious arrangement, is enabled to show that water is decomposed by the common machine;

and by using an electrical kite, he was able, in fine weather, to produce decomposition, although so slowly that only $\frac{1}{7000000}$th of a grain of water was decomposed per hour. Faraday has proved that the decomposition of one single grain of water produces more electricity than is contained in the most powerful flash of lightning.

ELECTRICITY IN BREWING.

Mr. Black, a practical writer upon Brewing, has found that by the practice of imbedding the fermentation-vats in the earth, and connecting them by means of metallic pipes, an electrical current passes through the beer and causes it to turn sour. As a preventive, he proposed to place the vats upon wooden blocks, or on any other non-conductors, so that they may be insulated. It has likewise been ascertained that several brewers who had brewed excellent ale on the south side of the street, on removing to the north have failed to produce good ale.

ELECTRIC PAPER.

Professor Schonbein has prepared paper, as transparent as glass and impermeable to water, which develops a very energetic electric force. By placing some sheets on each other, and simply rubbing them once or twice with the hand, it becomes difficult to separate them. If this experiment is performed in the dark, a great number of distinct flashes may be perceived between the separated surfaces. The disc of the electrophorus, placed on a sheet that has been rubbed, produces sparks of some inches in length. A thin and very dry sheet of paper, placed against the wall, will adhere strongly to it for several hours if the hand be passed only once over it. If the same sheet be passed between the thumb and fore-finger in the dark, a luminous band will be visible. Hence with this paper may be made powerful and cheap electrical machines.

DURATION OF THE ELECTRIC SPARK.

By means of Professor Wheatstone's apparatus, the Duration of the Electric Spark has been ascertained not to exceed the twenty-five-thousandth part of a second. A cannon-bail, f illumined in its flight by a flash of lightning, would, in consequence of the momentary duration of the light, appear to be stationary, and even the wings of an insect, that move ten thousand times in a second, would seem at rest.

VELOCITY OF ELECTRIC LIGHT.

On comparing the velocities of solar, stellar, and terrestrial light, which are all equally refracted in the prism, with the velocity of the light of frictional electricity, we are disposed, in accordance with Wheatstone's ingeniously-conducted experiments, to regard the lowest ratio in which the latter excels the former as 3 : 2. According to the lowest results of Wheatstone's apparatus, electric light traverses 288,000 miles in a second. If we reckon 189,938 miles for stellar light, according to Struve, we obtain the difference of 95,776 miles as the greater velocity of electricity in one second.

From the experiment described in Wheatstone's paper (*Philosophical Transactions* for 1834), it would appear that the human eye is capable of perceiving phenomena of light whose duration is limited to the millionth part of a second.

In Professor Airy's experiments with the electric telegraph to determine the difference of longitude between Greenwich and Brussels, the time spent by the electric current in passing from one observatory to the other (270 miles) was found to be 0·109″, or rather more than *the ninth part of a second;* and this determination rests on 2616 observations: a speed which would "girdle the globe" in ten seconds.

IDENTITY OF ELECTRIC AND MAGNETIC ATTRACTION.

This vague presentiment of the ancients has been verified in our own times. "When electrum (amber)," says Pliny, "is animated by friction and heat, it will attract bark and dry leaves precisely as the loadstone attracts iron." The same words may be found in the literature of an Asiatic nation, and occur in a eulogium on the loadstone by the Chinese physicist Knopho, in the fourth century: "The magnet attracts iron as amber does the smallest grain of mustard-seed. It is like a breath of wind, which mysteriously penetrates through both, and communicates itself with the rapidity of an arrow."

Humboldt observed with astonishment on the woody banks of the Orinoco, in the sports of the natives, that the excitement of electricity by friction was known to these savage races. Children may be seen to rub the dry, flat, and shining seeds or husks of a trailing plant until they are able to attract threads of cotton and pieces of bamboo-cane. What a chasm divides the electric pastime of these naked copper-coloured Indians from the discovery of a metallic conductor discharging its electric shocks, or a pile formed of many chemically-decomposing substances, or a light-engendering magnetic apparatus! In such a chasm lie buried thousands of years, that compose the history of the intellectual development of mankind.—*Humboldt's Cosmos*, vol. i.

THEORY OF THE ELECTRO-MAGNETIC ENGINE.

Several years ago a speculative American set the industrial world of Europe in excitement by this proposition. The Magneto-Electric Machines often made use of in the case of rheumatic disorders are well known. By imparting a swift rotation to the magnet of such a machine, we obtain powerful currents of electricity. If these be conducted through water, the latter will be reduced to its two components, oxygen and hydrogen. By the combustion of hydrogen water is again generated. If this combustion takes place, not in atmospheric air, in which oxygen only constitutes a fifth part, but in pure oxygen, and if a bit of chalk be placed in the flame, the chalk will be raised to a white heat, and give us the sun-like Drummond light: at the same time the flame develops a considerable quantity of heat. Now the American inventor proposed to utilise in this way the gases obtained from electrolytic decomposition; and asserted that by the combustion a sufficient amount of heat was generated to keep a small steam-engine in action, which again drove his magneto-electric machine, decomposed the water, and thus continually prepared its own fuel. This would certainly have been the most splendid of all discoveries,—a perpetual motion which, besides the force that kept it going, generated light like the sun, and warmed all around it. The affair, however, failed, as was predicted by those acquainted with the physical investigations which bear upon the subject. —*Professor Helmholtz.*

MAGNETIC CLOCK AND WATCH.

In the Museum of the Royal Society are two curiosities of the seventeenth century which are objects of much interest in association with the electric discoveries of our day. These are a Clock, described by the Count Malagatti (who accompanied Cosmo III., Grand Duke of Tuscany, to inspect the Museum in 1669) as more worthy of observation than all the other objects in the cabinet. Its "movements are derived from the vicinity of a loadstone, and it is so adjusted as to discover the distance of countries at sea by the longitude." The analogy between this clock and the electric clock of the present day is very remarkable. Of kindred interest is "Hook's Magnetic Watch," often alluded to in the Royal Society's Journal-book of 1669 as "going slower or faster according to the greater or less distance of the loadstone, and so moving regularly in any posture."

WHEATSTONE'S ELECTRO-MAGNETIC CLOCK.

In this ingenious invention, the object of Professor Wheatstone was to enable a simple clock to indicate exactly the same time in as many different places, distant from each other, as may be required. A standard clock in an observatory, for example, would thus keep in order another clock in each apartment, and that too with such accuracy, that *all of them, however numerous, will beat dead seconds audibly with as great pre-*

cision as the standard astronomical time-piece with which they are connected. But, besides this, the subordinate time-pieces thus regulated require none of the mechanism for maintaining or regulating the power. They consist simply of a face, with its second, minute, and hour hands, and a train of wheels which communicate motion from the action of the second-hand to that of the hour-hand, in the same manner as an ordinary clock-train. Nor is this invention confined to observatories and large establishments. The great horologe of St. Paul's might, by a suitable network of wires, or even by the existing metallic pipes of the metropolis, be made to command and regulate all the other steeple-clocks in the city, and even every clock within the precincts of its metallic bounds. As railways and telegraphs extend from London nearly to the remotest cities and villages, the sensation of time may be transmitted along with the elements of language; and the great cerebellum of the metropolis may thus constrain by its sympathies, and regulate by its power, the whole nervous system of the empire.

HOW TO MAKE A COMMON CLOCK ELECTRIC.

M. Kammerer of Belgium effects this by an addition to any clock whereby it is brought into contact with the two poles of a galvanic battery, the wires from which communicate with a drum moved by the clockwork; and every fifteen seconds the current is changed, the positive and the negative being transmitted alternately. A wire is continued from the drum to the electric clock, the movement of which, through the plate-glass dial, is seen to be two pairs of small straight electro-magnets, each pair having their ends opposite to the other pair, with about half an inch space between. Within this space there hangs a vertical steel bar, suspended from a spindle at the top. The rod has two slight projections on each side parallel to the ends of the wire-coiled magnets. When the electric current comes on the wire from the positive end of the battery (through the drum of the regulator-clock) the positive magnets attract the bar to it, the distance being perhaps the sixteenth of an inch. When, at the end of fifteen seconds, the negative pole operates, repulsion takes effect, and the bar moves to the opposite side. This oscillating bar gives motion to a wheel which turns the minute and hour hands.

M. Kammerer states, that if the galvanic battery be attached to any particular standard clock, any number of clocks, wherever placed, in a city or kingdom, and communicating with this by a wire, will indicate precisely the same time. Such is the precision, that the sounds of three clocks thus beating simultaneously have been mistaken as proceeding from one clock.

DR. FRANKLIN'S ELECTRICAL KITE.

Several philosophers had observed that lightning and electricity possessed many common properties; and the light which accompanied the explosion, the crackling noise made by the flame, and other phenomena, made them suspect that lightning might be electricity in a highly powerful state. But this connection was merely the subject of conjecture until, in the year 1750, Dr. Franklin suggested an experiment to determine the question. While he was waiting for the building of a spire at Philadelphia, to which he intended to attach his wire, the experiment was successfully made at Marly-la-Ville, in France, in the year 1752; when lightning was actually drawn from the clouds by means of a pointed wire, and it was proved to be really the electric fluid.

Almost every early electrical discovery of importance was made by Fellows of the Royal Society, and is to be found recorded in the *Philosophical Transactions*. In the forty-fifth volume occurs the first mention of Dr. Franklin's name, and his theory of positive and negative electricity. In 1756 he was elected into the Society, "without any fee or other payment." His previous communications to the *Transactions*, particularly the account of his electrical kite, had excited great interest. (*Weld's History of the Royal Society.*) It is thus described by him in a letter dated Philadelphia, October 1, 1752:

"As frequent mention is made in the public papers from Europe of the success of the Marly-la-Ville experiment for drawing the electric fire from clouds by means of pointed rods of iron erected on high buildings, &c., it may be agreeable to the curious to be informed that the same experiment has succeeded in Philadelphia, though made in a different and more easy manner, which any one may try, as follows:

Make a small cross of two light strips of cedar, the arms so long as to reach to the four corners of a large thin silk handkerchief when extended. Tie the corners of the handkerchief to the extremities of the cross; so you have the body of a kite, which, being properly accommodated with a tail, loop, and string, will rise in the air like a kite made of paper; but this, being of silk, is fitter to bear the wet and wind of a thunder-gust without tearing. To the top of the upright stick of the cross is to be fixed a very sharp-pointed wire, rising a foot or more above the wood. To the end of the twine, next the band, is to be tied a silk ribbon; and where the twine and silk join a key may be fastened.

The kite is to be raised when a thunder-gust appears to be coming on, and the person who holds the string must stand within a door or window, or under some cover, so that the silk ribbon may not be wet; and care must be taken that the twine does not touch the frame of the door or window. As soon as any of the thunder-clouds come over the kite, the pointed wire will draw the electric fire from them; and the kite, with all the twine, will be electrified; and the loose filaments of the twine will stand out every way, and be attracted by an approaching finger.

When the rain has wet the kite and twine, so that it can conduct the electric fire freely, you will find it stream out plentifully from the key on the approach of your knuckle. At this key the phial may be charged; and from electric fire thus obtained spirits may be kindled, and all the other electrical experiments be performed which are usually done by the help of a rubbed-glass globe or tube; and thus the sameness of the electric matter with that of lightning is completely demonstrated."—*Philosophical Transactions.*

Of all this great man's (Franklin's) scientific excellencies, the most remarkable is the smallness, the simplicity, the apparent inadequacy of the means which he employed in his experimental researches. His discoveries were all made with hardly any apparatus at all; and if at any time he had been led to employ instruments of a somewhat less ordinary description, he never rested satisfied until he had, as it were, afterwards translated the process by resolving the problem with such simple machinery that you might say he had done it wholly unaided by apparatus. The experiments by which the identity of lightning and electricity was demonstrated were made with a sheet of brown paper, a bit of twine or silk thread, and an iron key!—*Lord Brougham.**

FATAL EXPERIMENT WITH LIGHTNING.

These experiments are not without danger; and a flash of lightning has been found to be a very unmanageable instrument. In 1753, M. Richman, at St. Petersburg, was making an experiment of this kind by drawing lightning into his room, when, incautiously bringing his head too near the wire, he was struck dead by the flash, which issued from it like a globe of blue fire, accompanied by a dreadful explosion.

FARADAY'S ELECTRICAL ILLUSTRATIONS.

The following are selected from the very able series of lectures delivered by Professor Faraday at the Royal Institution:

The Two Electricities.—After having shown by various experiments the attractions and repulsions of light substances from excited glass and from an excited tube of gutta-percha, Professor Faraday proceeds to point out the difference in the character of the electricity produced by the friction of the two substances. The opposite characters of the electricity evolved by the friction of glass and of that excited by the friction of gutta-percha and shellac are exhibited by several experiments, in which the attraction of the positive and negative electricities to each other and the neutralisation of electrical action on the combination of the two forces are distinctly observable. Though adopting the terms "positive" and "negative" in distinguishing the electricity excited by glass from that excited by gutta-percha and resinous bodies, Professor Faraday is strongly opposed to the Franklinian theory from which these terms are derived. According to Franklin's view of the nature of electrical excitement, it arises from the disturbance, by friction or other means, of the natural quantity of one electric fluid which is possessed by all bodies; an excited piece of glass having more than its natural share, which has been taken from the rubber, the latter being consequently in a minus or negative state. This theory Professor Faraday considers to be opposed to the distinct characteristic actions of the two forces; and, in his opinion, it is impossible to deprive any body of electricity, and reduce it to the minus state of Franklin's hypothesis. Taking a Zamboni's pile, he applies its two ends separately to an electrometer, to show that each end produces opposite kinds of electricity, and that the zero, or absence of electrical excitement, only exists in the centre of the pile. To prove how completely the two electricities neutralise each other, an excited rod of gutta-percha and the piece of flannel with which it has been rubbed are laid on the top of the electrometer without any sign of electricity whilst they are together; but when either is removed, the gold leaves diverge with positive and negative electricity alternately. The Professor dwells strongly on the peculiarity of the dual force of electricity, which, in respect of its duality, is unlike any other force in nature. He then contrasts its phenomena of instantaneous conduction with those of the somewhat analogous force of heat; and he illustrates by several striking experiments the peculiar property which static electricity possesses of being spread only over the surfaces of bodies. A metal ice-pail is placed on an insulated stand and electrified, and a metal ball suspended by a string is introduced, and touches the bottom and sides without having any electricity imparted to it, but on touching the outside it becomes strongly electrical. The experiment is repeated with a wooden tub with the same result; and Professor Faraday mentions the still more remarkable manner in which he has proved the surface distribution of electricity by having a small chamber constructed and covered with tinfoil, which can be insulated; and whilst torrents of electricity are being evolved from the external surface, he enters it with a galvanometer, and cannot perceive the slightest manifestation of electricity within.

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* This illustration, it will be seen, does not literally correspond with the details which precede it.

The Two Threads.—A curious experiment is made with two kinds of thread used as the conducting force. From the electric machine on the table a silk thread is first carried to the indicator a yard or two off, and is shown to be a non-conductor when the glass tube is rubbed and applied to the machine (although the silk, when wetted, conducted); while a metallic thread of the same thickness, when treated in the same way, conducts the force so much as to vehemently agitate the gold leaves within the indicator.

Non-conducting Bodies.—The action that occurs in bodies which cannot conduct is the most important part of electrical science. The principle is illustrated by the attraction and repulsion of an electrified ball of gilt paper by a glass tube, between which and the ball a sheet of shellac is suspended. The nearer a ball of another description—an unelectrical insulated body—is brought to the Leyden jar when charged, the greater influence it is seen to possess over the gold leaf within the indicator, by induction, not by conduction. The questions, how electricities attract each other, what kind of electricity is drawn from the machine to the hand, how the hand was electric, are thus illustrated. To show the divers operations of this wonderful force, a tub (a bad conductor) is placed by the electric machine. When the latter is charged, a ball, having been electrified from it, is held in the tub, and rattles against its sides and bottom. On the application of the ball to the indicator, the gold leaf is shown not to move, whereas it is agitated manifestly when the same process is gone through with the exception that the ball is made to touch the outside only of the tub. Similar experiments with a ball in an ice-pail and a vessel of wire-gauze, into the latter of which is introduced a mouse, which is shown to receive no shock, and not to be frightened at all; while from the outside of the vessel electric sparks are rapidly produced. This latter demonstration proves that, as the mouse, so men and women, might be safe inside a building with proper conductors while lightning played about the exterior. The wire-gauze being turned inside out, the principle is shown to be irreversible in spite of the change—what has been the unelectrical inside of the vessel being now, when made the outside portion, capable of receiving and transmitting the power, while the original outside is now unelectrical.

Repulsion of Bodies.—A remarkable and playful experiment, by which the repulsion of bodies similarly electrified is illustrated, consists in placing a basket containing a heap of small pieces of paper on an insulated stand, and connecting it with the prime conductor of the electrical machine; when the pieces of paper rise rapidly after each other into the air, and descend on the lecture-table like a fall of snow. The effect is greatly increased when a metal disc is substituted for the basket.

ORIGIN OF THE LEYDEN JAR.

Muschenbroek and Linnæus had made various experiments of a strong kind with water and wire. The former, as appears from a letter of his to Réaumur, filled a small bottle with water, and having corked it up, passed a wire through the cork into the bottle. Having rubbed the vessel on the outside and suspended it to the electric machine, he was surprised to find that on trying to pull the wire out he was subjected to an awfully severe shock in his joints and his whole body, such as he declared he would not suffer again for any experiment. Hence the Leyden jar, which owes its name to the University of Leyden, with which, we believe, Muschenbroek was connected.—*Faraday.*

DANGER TO GUNPOWDER MAGAZINES.

By the illustration of a gas globule, which is ignited from a spark by induction, Mr. Faraday has proved in a most interesting manner that the corrugated-iron roofs of some gunpowder-magazines,—on the subject of which he had often been consulted by the builders, with a view to the greater safety of these manufactories,—are absolutely dangerous by the laws of induction; as, by the return of induction, while a storm was discharging itself a mile or two off, a secondary spark might ignite the building.

ARTIFICIAL CRYSTALS AND MINERALS.—"THE CROSSE MITE."

Among the experimenters on Electricity in our time who have largely contributed to the "Curiosities of Science," Andrew Crosse is entitled to special notice. In his school-days he became greatly attached to the study of electricity; and on settling on his paternal estate, Fyne Court, on the Quantock Hills in Somersetshire, he there devoted himself to chemistry, mineralogy, and electricity, pursuing his experiments wholly independently of theories, and searching only for facts. In Holwell Cavern, near his residence, he observed the sides and the roof covered with Arragonite crystallisations, when his observations led him to conclude that the crystallisations were the effects, at least to some extent, of electricity. This induced him to make the attempt to form artificial crystals by the same means, which he began in 1807. He took some water from the cave, filled a tumbler, and exposed it to the action of a voltaic battery excited by water alone, letting the platinum-wires of the battery fall on opposite sides of the tumbler from the opposite poles of the battery. After ten days' constant action, he produced crystals of carbonate of lime; and on repeating the experiment in the dark, he produced them in six days. Thus Mr. Crosse simulated in his laboratory one of the hitherto most mysterious processes of nature.

He pursued this line of research for nearly thirty years at Fyne Court, where his electrical-room and laboratory were on an enormous scale: the apparatus had cost some thousands of pounds, and the house was nearly full of furnaces. He carried an insulated wire above the tops of the trees around his house to the length of a mile and a quarter, afterwards shortened to 1800 feet. By this wire, which was brought into connection with the apparatus in a chamber, he was enabled to see continually the changes in the state of the atmosphere, and could use the fluid so collected for a variety of purposes. In 1816, at a meeting of country gentlemen, he prophesied that, "by means of electrical agency, we shall be able to communicate our thoughts simultaneously with the uttermost ends of the earth." Still, though he foresaw the powers of the medium, he did not make any experiments in that direction, but confined himself to the endeavour to produce crystals of various kinds. He ultimately obtained forty-one mineral crystals, or minerals uncrystallised, in the form in which they are produced by nature, including one sub-sulphate of copper—an entirely new mineral, neither found in nature nor formed by art previously. His belief was that even diamonds might be produced in this way.

Mr. Crosse worked alone in his retreat until 1836, when, attending the meeting of the British Association at Bristol, he was induced to explain his experiments, for which he was highly complimented by Dr. Buckland, Dr. Dalton, Professor Sedgwick, and others.*

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* Mr. Crosse gave to the meeting a general invitation to Fyne Court; one of he first to accept which was Sir Richard Phillips, who, on his return to Brigh-on, described in a very attractive manner, at the Sussex Institution, Mr. Crosse's

Shortly after Mr. Crosse's return to Fyne Court, while pursuing his experiments for forming crystals from a highly caustic solution out of contact with atmospheric air, he was greatly surprised by the appearance of an insect. Black flint, burnt to redness and reduced to powder, was mixed with carbonate of potash, and exposed to a strong heat for fifteen minutes; and the mixture was poured into a black-lead crucible in an air furnace. It was reduced to powder while warm, mixed with boiling water, kept boiling for some minutes, and then hydrochloric acid was added to supersaturation. After being exposed to voltaic action for twenty-six days, a perfect insect of the Acari tribe made its appearance, and in the course of a few weeks about a hundred more. The experiment was repeated in other chemical fluids with the like results; and Mr. Weeks of Sandwich afterwards produced the Acari in ferrocyanerret of potassium. The Acarus of Mr. Crosse was found to contribute a new species of that genus, nearly approaching the Acari found in cheese and flour, or more nearly, Hermann's *Acarus dimidiatus*.

This discovery occasioned great excitement. The possibility was denied, though Mr. Faraday is said to have stated in the same year that he had seen similar appearances in his own electrical experiments. Mr. Crosse was now accused of impiety and aiming at creation, to which attacks he thus replied:

> As to the appearance of the acari under long-continued electrical action, I have never in thought, word, or deed given any one a right to suppose that I considered them as a creation, or even as a formation, from inorganic matter. To create is to form a something out of a nothing. To annihilate is to reduce that something to a nothing. Both of these, of course, can only be the attributes of the Almighty. In fact, I can assure you most sacredly that I have never dreamed of any theory sufficient to account for their appearance. I confess that I was not a little surprised, and am so still, and quite as much as I was when the acari made their first appearance. Again, I have never claimed any merit as attached to these experiments. It was a matter of chance; I was looking for silicious formations, and animal matter appeared instead.

These Acari, if removed from their birthplace, lived and propagated; but uniformly died on the first recurrence of frost, and were entirely destroyed if they fell back into the fluid whence they arose.

One of Mr. Crosse's visitors thus describes the vast electrical room at Fyne Court:

> Here was an immense number of jars and gallipots, containing fluids on which electricity was operating for the production of crystals. But you are startled in the midst of your observations by the smart crackling sound that attends the passage of the electrical spark; you hear also

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experiments and apparatus; a report of which being communicated to the *Brighton Herald*, was quoted in the *Literary Gazette*, and thence copied generally into the newspapers of the day.

the rumbling of distant thunder. The rain is already plashing in great drops against the glass, and the sound of the passing sparks continues to startle your ear; you see at the window a huge brass conductor, with a discharging rod near it passing into the floor, and from the one knob to the other sparks are leaping with increasing rapidity and noise, every one of which would kill twenty men at one blow, if they were linked together hand in hand and the spark sent through the circle. From this conductor wires pass off without the window, and the electric fluid is conducted harmlessly away. Mr. Crosse approached the instrument as boldly as if the flowing stream of fire were a harmless spark. Armed with his insulated rod, he sent it into his batteries: having charged them, he showed how wire was melted, dissipated in a moment, by its passage; how metals—silver, gold, and tin—were inflamed and burnt like paper, only with most brilliant hues. He showed you a mimic aurora and a falling-star, and so proved to you the cause of those beautiful phenomena.

Mr. Crosse appears to have produced in all "about 200 varieties of minerals, exactly resembling in all respects similar ones found in nature." He tried also a new plan of extracting gold from its ores by an electrical process, which succeeded, but was too expensive for common use. He was in the habit of saying that he could, like Archimedes, move the world "if he were able to construct a battery at once cheap, powerful, and durable." His process of extracting metals from their ores has been patented. Among his other useful applications of electricity are the purifying by its means of brackish or sea water, and the improving bad wine and brandy. He agreed with Mr. Quekett in thinking that it is by electrical action that silica and other mineral substances are carried into and assimilated by plants. Negative electricity Mr. Crosse found favourable to no plants except fungi; and positive electricity he ascertained to be injurious to fungi, but favourable to every thing else.

Mr. Crosse died in 1855. His widow has published a very interesting volume of *Memorials* of the ingenious experimenter, from which we select the following:

On one occasion Mr. Crosse kept a pair of soles under the electric action for three months; and at the end of that time they were sent to a friend, whose domestics knew nothing of the experiment. Before the cook dressed them, her master asked her whether she thought they were fresh, as he had some doubts. She replied that she was sure they were fresh; indeed, she said she could swear that they were alive yesterday! When served at table they appeared like ordinary fish; but when the family attempted to eat them, they were found to be perfectly tasteless—the electric action had taken away all the essential oil, leaving the fish unfit for food. However, the process is exceedingly useful for keeping fish, meat, &c. fresh and *good* for ten days or a fortnight. I have never heard a satisfactory explanation of the cause of the antiseptic power communicated to water by the passage of the electric current. Whether ozone has not something to do with it, may be a question. The same effect is produced whichever two dissimilar metals are used.

The Electric Telegraph.

ANTICIPATIONS OF THE ELECTRIC TELEGRAPH.

THE great secret of ubiquity, or at least of instantaneous transmission, has ever exercised the ingenuity of mankind in various romantic myths; and the discovery of certain properties of the loadstone gave a new direction to these fancies.

The earliest anticipation of the Electric Telegraph of this purely fabulous character forms the subject of one of the *Prolusiones Academicæ* of the learned Italian Jesuit Strada, first published at Rome in the year 1617. Of this poem a free translation appeared in 1750. Strada's fancy was this: "There is," he supposes, "a species of loadstone which possesses such virtue, that if two needles be touched with it, and then balanced on separate pivots, and the one be turned in a particular direction, the other will sympathetically move parallel to it. He then directs each of these needles to be poised and mounted parallel on a dial having the letters of the alphabet arranged round it. Accordingly, if one person has one of the dials, and another the other, by a little pre-arrangement as to details a correspondence can be maintained between them at any distance by simply pointing the needles to the letters of the required words. Strada, in his poetical reverie, dreamt that some such sympathy might one day be found to hold up the Magnesian Stone."

Strada's conceit seems to have made a profound impression on the master-minds of the day. His poem is quoted in many works of the seventeenth and eighteenth centuries; and Bishop Wilkins, in his book on Cryptology, is strangely afraid lest his readers should mistake Strada's fancy for fact. Wilkins writes: "This invention is altogether imaginary, having no foundation in any real experiment. You may see it frequently confuted in those that treat concerning magnetical virtues."

Again, Addison, in the 241st No. of the *Spectator*, 1712, describes Strada's "Chimerical correspondence," and adds that, "if ever this invention should be revived or put in practice," he "would propose that upon the lover's dial-plate there should be written not only the four-and-twenty letters, but several entire words which have always a place in passionate epistles, as flames, darts, die, language, absence, Cupid, heart, eyes, being, drown, and the like. This would very much abridge the lover's pains in this way of writing a letter, as it would enable him to express the most useful and significant words with a single touch of the needle."

After Strada and his commentators comes Henry Van Etten, who shows how "Claude, being at Paris, and John at Rome, might converse together, if each had a needle touched by a stone of such virtue that as one moved itself at Paris the other should be moved at Rome:" he adds, "it is a fine invention, but I do not think there is a magnet in the world which has such virtue; besides, it is inexpedient, for treasons would be too frequent and too much protected. (*Recrēations Mathēmatiques:* see 5th edition, Paris, 1660, p. 158.) Sir Thomas Browne refers to this "conceit" as "excellent, and, if the effect would follow, somewhat divine;" but he tried the two needles touched with the same loadstone, and placed in two circles of letters, "one friend keeping one and another the other, and agreeing upon an hour when they will communicate," and found the tradition a failure that, "at what distance of place soever, when one needle shall be removed unto any letter, the other, by a wonderful sympathy, will move unto the same." (See *Vulgar Errors*, book ii. ch. iii.)

Glanvill's *Vanity of Dogmatizing*, a work published in 1661, however, contains the most remarkable allusion to the prevailing telegraphic fancy. Glanvill was an enthusiast, and he clearly predicts the discovery and general adoption of the electric telegraph. "To confer," he says, "at the distance of the Indies by sympathetic conveyance may be as usual to future times as to us in a literary correspondence." By the word "sympathetic" he evidently intended to convey magnetic agency; for he subsequently treats of "conference at a distance by impregnated needles," and describes the device substantially as it is given by Sir Thomas Browne, adding, that though it did not then answer, "by some other such way of magnetic efficiency it may hereafter with success be attempted, when magical history shall be enlarged by riper inspection; and 'tis not unlikely but that present discoveries might be improved to the performance." This may be said to close the most speculative or mythical period in reference to the subject of electro-telegraphy.

Electricians now began to be sedulous in their experiments upon the new force by friction, then the only known method of generating electricity. In 1729, Stephen Gray, a pensioner of the Charter-house, contrived a method of making electrical signals through a wire 765 feet long; yet this most important experiment did not excite much attention. Next Dr. Watson, of the Royal Society, experimented on the possibility of transmitting electricity through a large circuit from the simple fact of Le Monnier's account of his feeling the stroke of the electrified fires through two of the basins of the Tuileries (which occupy nearly an acre), by means of an iron chain lying upon the ground and stretched round half their circumference. In 1745, Dr. Watson, assisted by several members of the Royal Society, made a series of experiments to ascertain how far electricity could be conveyed by means of conductors. "They caused the shock to pass across the Thames at Westminster Bridge, the circuit being completed by making use of the river for one part of the chain of communication. One end of the wire communicated with the coating of a charged phial, the other being held by the observer, who in his other hand held an iron rod which he dipped into the river. On the opposite side of the river stood a gentleman, who likewise dipped an iron rod in the river with one hand, and in the other held a wire the extremity of which might be brought into contact with the wire of the phial. Upon making the discharge, the shock was felt simultaneously by both the observers." (*Priestley's History of Electricity.*) Subsequently the same parties made experiments near Shooter's Hill, when the wires formed a circuit of four miles, and conveyed the shock with equal facility,—"a distance which without trial," they observed, "was too great to be credited."* These experiments in 1747 established two great principles: 1, that the electric current is transmissible along nearly two miles and a half of iron wire; 2, that the electric current may be completed by burying the poles in the earth at the above distance.

In the following year, 1748, Benjamin Franklin performed his celebrated experiments on the banks of the Schuylkill, near Philadelphia; which being interrupted by the hot weather, they were concluded by a picnic, when spirits were fired by an electric spark sent through a wire in the river, and a turkey was killed by the electric shock, and roasted by the electric jack before a fire kindled by the electrified bottle.

In the year 1753, there appeared in the *Scots' Magazine*, vol. xv., definite proposals for the construction of an electric telegraph, requiring as many conducting wires as there are letters in the alphabet; it was also proposed to converse by chimes, by substituting bells for the balls. A similar system of telegraphing was next invented by Joseph Bozolus, a Jesuit, at Rome; and next by the great Italian electrician Tiberius Cavallo, in his treatise on Electricity.

In 1787, Arthur Young, when travelling in France, saw a model working telegraph by M. Lomond: "You write two or three words on a paper," says Young; "he takes it with him into a room, and turns a machine enclosed in a cylindrical case, at the top of which is an electrometer—a small fine pith-ball; a wire connects with a similar cylinder and electrometer in a distant apartment; and his wife, by remarking the corresponding motions of the ball, writes down the words they indicate: from which it appears that he has formed an alphabet of motions. As the length of the wire makes no difference in the effect, a correspondence might be carried on at any distance. Whatever the use may be, the invention is beautiful."

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* These experiments were performed at the expense of the Royal Society, and cost 10*l*. 5*s*. 6*d*. In the Paper detailing the experiments, printed in the 45th volume of the *Philosophical Transactions*, occurs the first mention of Dr. Franklin's name, and of his theory of positive and negative electricity.—*Weld's Hist. Royal Soc.* vol. i. p. 467.

We now reach a new epoch in the scientific period—the discovery of the Voltaic Pile. In 1794, according to *Voigt's Magazine*, Reizen made use of the electric spark for the telegraph; and in 1798 Dr. Salva of Madrid constructed a similar telegraph, which the Prince of Peace subsequently exhibited to the King of Spain with great success.

In 1809, Soemmering exhibited a telegraphic apparatus worked by galvanism before the Academy of Sciences at Munich, in which the mode of signalling consisted in the development of gas-bubbles from the decomposition of water placed in a series of glass tubes, each of which denoted a letter of the alphabet. In 1813, Mr. Sharpe, of Doe Hill near Alfreton, devised a *voltaic*-electric telegraph, which he exhibited to the Lords of the Admiralty, who spoke approvingly of it, but declined to carry it into effect. In the following year, Soemmering exhibited a *voltaic*-electric telegraph of his own construction, which, however, was open to the objection of there being as many wires as signs or letters of the alphabet.

The next invention is of much greater importance. Upon the suggestion of Cavallo, already referred to, Francis Ronalds constructed a perfect electric telegraph, employing frictional electricity notwithstanding Volta's discoveries had been known in England for sixteen years. This telegraph was exhibited at Hammersmith in 1816:* it consisted of a single insulated wire, the indication being by pith-balls in front of a dial. When the wire was charged, the balls were divergent, but collapsed when the wire was discharged; at the same time were employed two clocks, with lettered discs for the signals. "If, as Paley asserts (and Coleridge denies), 'he alone discovers who proves,' Ronalds is entitled to the appellation of the first discoverer of an efficient electric telegraph." (*Saturday Review*, No. 147 †) Nevertheless the Government of the day refused to avail itself of this admirable contrivance.

In 1819, Oersted made his great discovery of the deflection, by a current of electricity, of a magnetic needle at right angles to such current. Dr. Hamel of St. Petersburg states that Baron Schilling was the first to apply Oersted's discovery to telegraphy; Ampère had previously suggested it, but his plan was very complicated, and Dr. Hamel maintains that Schilling first realised the idea by actually producing an electro-magnetic telegraph simpler in construction than that which Ampère had *imagined.* In 1836, Professor Muncke of Heidelberg, who had inspected Schilling's telegraphic apparatus, explained the same to William Fothergill Cooke, who in the following year returned to England, and subsequently, with Professor Wheatstone, laboured simultaneously for the introduction of the electro-magnetic telegraph upon the English railways; the first patent for which was taken out in the joint names of these two gentlemen.

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* In this year Andrew Crosse said: "I prophesy that by means of the electric agency we shall be enabled to communicate our thoughts instantaneously with the uttermost parts of the earth."

† To which paper the writer is indebted for many of these details.

In 1844, Professor Wheatstone, with one of his telegraphs, formed a communication between King's College and the lofty shot-tower on the opposite bank of the Thames: the wire was laid along the parapets of the terrace of Somerset House and Waterloo Bridge, and thence to the top of the tower, about 150 feet high, where a telegraph was placed; the wire then descended, and a plate of zinc attached to its extremity was plunged into the mud of the river, whilst a similar plate attached to the extremity at the north side was immersed in the water. The circuit was thus completed by the entire breadth of the Thames, and the telegraph acted as well as if the circuit were entirely metallic.

Shortly after this experiment, Professor Wheatstone and Mr. Cooke laid down the first working electric telegraph on the Great Western Railway, from Paddington to Slough.

ELECTRIC GIRDLE FOR THE EARTH.

One of our most profound electricians is reported to have exclaimed: "Give me but an unlimited length of wire, with a small battery, and I will girdle the universe with a sentence in forty minutes." Yet this is no vain boast; for so rapid is the transition of the electric current along the line of the telegraph wire, that, supposing it were possible to carry the wires eight times round the earth, the transit would occupy but *one second of time!*

CONSUMPTION OF THE ELECTRIC TELEGRAPH.

It is singular to see how this telegraphic agency is measured by the chemical consumption of zinc and acid. Mr. Jones (who has written a work upon the Electric Telegraphs of America) estimates that to work 12,000 miles of telegraph about 3000 zinc cups are used to hold the acid: these weigh about 9000 lbs., and they undergo decomposition by the galvanic action in about six months, so that 18,000 lbs. of zinc are consumed in a year. There are also about 3600 porcelain cups to contain nitric acid; it requires 450 lbs. of acid to charge them once, and the charge is renewed every fortnight, making about 12,000 lbs. of nitric acid in a year.

TIME LOST IN ELECTRIC MESSAGES.

Although it may require an hour, or two or three hours, to transmit a telegraphic message to a distant city, yet it is the mechanical adjustment by the sender and receiver which really absorbs this time; the actual transit is practically instantaneous, and so it would be from here to the antipodes, so far as the current itself is concerned.

THE ELECTRIC TELEGRAPH IN ASTRONOMY AND THE DETERMINATION OF LONGITUDE.

The Electric Telegraph has become an instrument in the hands of the astronomer for determining the difference of longitude between two observatories. Thus in 1854 the difference of longitude between London and Paris was determined within a limit of error which amounted barely to a quarter of a second. The sudden disturbances of the magnetic needle, when freely suspended, which seem to take place simultaneously over whole continents, if not over the whole globe, from some unexplained cause, are pointed out as means by which the differences of longitude between the magnetic observatories may possibly be determined with greater precision than by any yet known method.

So long ago as 1839 Professor Morse suggested some experiments for the determination of Longitudes; and in June 1844 the difference of longitude between Washington and Baltimore was determined by electric means under his direction. Two persons were stationed at these two towns, with clocks carefully adjusted to the respective spots; and a telegraphic signal gave the means of comparing the two clocks at a given instant. In 1847 the relative longitudes of New York, Philadelphia, and Washington were determined by means of the electric telegraph by Messrs. Keith, Walker, and Loomis.

NON-INTERFERENCE OF GALVANIC WAVES ON THE SAME WIRE.

One of the most remarkable facts in the economy of the telegraph is, that the line, when connected with a battery in action, propagates the hydro-galvanic waves in either direction without interference. As several successive syllables of sound may set out in succession from the same place, and be on their way at the same time, to a listener at a distance, so also, where the telegraph-line is long enough, several waves may be on their way from the signal station before the first one reaches the receiving station; two persons at a distance may pronounce several syllables at the same time, and each hear those emitted by the other. So, on a telegraph-line of two or three thousand miles in length in the air, and the same in the ground, two operators may at the same instant commence a series of several dots and lines, and each receive the other's writings, though the waves have crossed each other on the way.

EFFECT OF LIGHTNING UPON THE ELECTRIC TELEGRAPH.

In the storm of Sunday April 2, 1848, the lightning had a very considerable effect on the wires of the electric telegraph, particularly on the line of railway eastward from Manchester to Normanton. Not only were the needles greatly deflected, and their power of answering to the handles considerably weakened, but those at the Normanton station were found to have had their poles reversed by some action of the electric fluid in the atmosphere. The damage, however, was soon repaired, and the needles again put in good working order.

ELECTRO-TELEGRAPHIC MESSAGE TO THE STARS.

The electric fluid travels at the mean rate of 20,000 miles in a second under ordinary circumstances; therefore, if it were possible to establish a telegraphic communication with the star 61 Cygni, it would require ninety years to send a message there.

Professor Henderson and Mr. Maclear have fully confirmed the annual parallax of *a* Centauri to amount to a second of arc, which gives about twenty billions of miles as its distance from our system; a ray of light would arrive from *a* Centauri to us in little more than three years, and a telegraphic despatch would arrive there in thirty years.

THE ATLANTIC TELEGRAPH.

The telegraphic communication between England and the United States is so grand a conception, that it would be impossible to detail its scientific and mechanical relations within the limits of the present work. All that we shall attempt, therefore, will be to glance at a few of the leading operations.

In the experiments made before the Atlantic Telegraph was finally decided on, 2000 miles of subterranean and submarine telegraphic wires, ramifying through England and Ireland and under the waters of the Irish Sea, were specially connected for the purpose; and through this distance of 2000 miles 250 distinct signals were recorded and printed in one minute.

First, as to the *Cable*. In the ordinary wires by the side of a railway the electric current travels on with the speed of lightning—uninterrupted by the speed of lightning; but when a wire is encased in gutta-percha, or any similar covering, for submersion in the sea, new forces come into play. The electric excitement of the wire acts by induction, through the envelope, upon the particles of water in contact with that envelope, and calls up an electric force of an opposite kind. There are two forces, in fact, pulling against each other through the gutta-percha as a neutral medium,—that is, the electricity in the wire, and the opposite electricity in the film of water immediately surrounding the cable; and to that extent the power of the current in the enclosed wire is weakened. A submarine cable, when in the water, is virtually *a lengthened-out Leyden jar;* it transmits signals while being charged and discharged, instead of merely allowing a stream to flow evenly along it: it is a *bottle* for holding electricity rather than a *pipe* for carrying it; and this has to be filled for every time of using. The wire being carried underground, or through the water, the speed becomes quite measurable, say a thousand miles in a second, instead of two hundred thousand, owing to the retardation by induced or retrograde currents. The energy of the currents and the quality of the wire also affect the speed. Until lately it was supposed that the wire acts only as a *conductor* of electricity, and that a long wire must produce a weaker effect than a short one, on account of the consequent attenuation of the electrical influence; but it is now known that, the cable being a *reservoir* as well as a conductor, its electrical supply is increased in proportion to its length.

The electro-magnetic current is employed, since it possesses a treble velocity of transmission, and realises consequently *a threefold working speed* as compared with simple voltaic electricity. Mr. Wildman Whitehouse has determined by his ingenious apparatus that the speed of the voltaic current might be raised under special circumstances to 1800 miles per second; but that of the induced current, or the electro-magnetic, might be augmented to 6000 miles per second.

Next as to a *Quantity Battery* employed in these investigations. To effect a charge, and transmit a current through some thousand miles of the Atlantic Cable, Mr. Whitehouse had a piece of apparatus prepared consisting of twenty-five pairs of zinc and silver plates about the 20th part of a square inch large, and the pairs so arranged that they would hold a drop of acidulated water or brine between them. On charging this Lilliputian battery by dipping the plates in salt and water, messages were sent from it through a thousand miles of cable with the utmost ease; and not only so,—pair after pair was dropped out from the series, the messages being still sent on with equal facility, until at last only a single pair, charged by one single drop of liquid, was used. Strange to say, with this single pair and single drop distinct signals were effected through the thousand miles of the cable! Each signal was registered at the end of the cable in less than three seconds of time.

The entire length of wire, iron and copper, spun into the cable amounts to 332,500 miles, a length sufficient to engirdle the earth thirteen times. The cable weighs from 19 cwt. to a ton per mile, and will bear a strain of 5 tons.

The *Perpetual Maintenance Battery*, for working the cable at the bottom of the sea, consists of large plates of platinated silver and amalgamated zinc, mounted in cells of gutta-percha. The zinc plates in each cell rest upon a longitudinal bar at the bottom, and the silver plates hang upon a similar bar at the top of the cell; so that there is virtually but a single stretch of silver and a single stretch of zinc in operation. Each of the ten cells contains 2000 square inches of acting surface; and the combination is so powerful, that when the broad strips of copper-plate which form the polar extensions are brought into contact or separated, brilliant flashes are produced, accompanied by a loud crackling sound. The points of large pliers are made red-hot in five seconds when placed between them, and even screws burn with vivid scintillation. The cost of maintaining this magnificent ten-celled Titan battery at work does not exceed a shilling per hour. The voltaic current generated in this battery is not, however, the electric stream to be sent across the Atlantic, but is only the primary power used to call up and stimulate the energy of a more speedy traveller by a complicated apparatus of "Double Induction Coils." Nor is the transmission-current generated in the inner wire of the double induction coil,—and which becomes weakened when it has passed through 1800 or 1900 miles,—set to work to print or record the signals transmitted. This weakened current merely opens and closes the outlet of a fresh battery, which is to do the printing labour. This relay-instrument (as it is called), which consists of a temporary and permanent magnet, is so sensitive an apparatus, that it may be put in action by a fragment of zinc and a sixpence pressed against the tongue.

The attempts to lay the cable in August 1857 failed through stretching it so tightly that it snapped and went to the bottom, at a depth of 12,000 feet, forty times the height of St. Paul's.

This great work was resumed in August 1858; and on the 5th the first signals were received through *two thousand and fifty miles* of the Atlantic Cable. And it is worthy of remark, that just 111 years previously, on the 5th of August 1747, Dr. Watson astonished the scientific world by practically proving that the electric current could be transmitted through a *wire hardly two miles and a half long.**

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* These illustrations have been in the main selected and abridged from papers in the *Companion to the Almanac*, 1858, and the *Penny Cyclopædia*, 2d supp.

Miscellanea.

HOW MARINE CHRONOMETERS ARE RATED AT THE ROYAL OBSERVATORY, GREENWICH.

The determination of the Longitude at Sea requires simply accurate instruments for the measurement of the positions of the heavenly bodies, and one or other of the two following,—either perfectly correct watches—or chronometers, as they are now called—or perfectly accurate tables of the lunar motions.

So early as 1696 a report was spread among the members of the Royal Society that Sir Isaac Newton was occupied with the problem of finding the longitude at sea; but the rumour having no foundation, he requested Halley to acquaint the members "that he was not about it."* (*Sir David Brewster's Life of Newton.*)

In 1714 the legislature of Queen Anne passed an Act offering a reward of 20,000*l.* for the discovery of the longitude, the problem being then very inaccurately solved for want of good watches or lunar tables. About the year 1749, the attention of the Royal Society was directed to the improvements effected in the construction of watches by John Harrison, who received for his inventions the Copley Medal. Thus encouraged, Harrison continued his labours with unwearied diligence, and produced in 1758 a timekeeper which was sent for trial on a voyage to Jamaica. After 161 days the error of the instrument was only $1^m\ 5^s$, and the maker received from the nation 5000*l.* The Commissioners of the Board of Longitude subsequently required Harrison to construct under their inspection chronometers of a similar nature, which were subjected to trial in a voyage to Barbadoes, and performed with such accuracy, that, after having fully explained the principle of their construction to the commissioners, they awarded him 10,000*l.* more; at the same time Euler of Berlin and the heirs of Mayer of Göttingen received each 3000*l.* for their lunar tables.

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* Newton was, however, much pestered with inquirers; and a Correspondent of the *Gentleman's Magazine*, in 1784, relates that he once had a transient view of a Ms. in Pope's handwriting, in which he read a verified anecdote relating to the above period. Sir Isaac being often interrupted by ignorant pretenders to the discovery of the longitude, ordered his porter to inquire of every stranger who desired admission whether he came about the longitude, and to exclude such as answered in the affirmative. Two lines in Pope's Ms., as the Correspondent recollects, ran thus:

"'Is it about the longitude you come?'
The porter asks: 'Sir Isaac 's not at home.'"

The account of the trial of Harrison's watch is very interesting. In April 1766, by desire of the Commissioners of the Board, the Lords of the Admiralty delivered the watch into the custody of the Astronomer-Royal, the Rev. Dr. Nevil Maskelyne. It was then placed at the Royal Observatory at Greenwich, in a box having two different locks, fixed to the floor or wainscot, with a plate of glass in the lid of the box, so that it might be compared as often as convenient with the regulator and the variation set down. The form observed by Mr. Harrison in winding up the watch was exactly followed; and an officer of Greenwich Hospital attended every day, at a stated hour, to see the watch wound up, and its comparison with the regulator entered. A key to one of the locks was kept at the Hospital for the use of the officer, and the other remained at the Observatory for the use of the Astronomer-Royal or his assistant.

The watch was then tried in various positions till the beginning of July; and from thence to the end of February following in a horizontal position with its face upwards.

The variation of the watch was then noted down. and a register was kept of the barometer and thermometer; and the time of comparing the same with the regulator was regularly kept, and attested by the Astronomer-Royal or his assistant and such of the officers as witnessed the winding-up and comparison of the watch.

Under these conditions Harrison's watch was received by the Astronomer-Royal at the Admiralty on May 5, 1766, in the presence of Philip Stephens, Esq., Secretary of the Admiralty; Captain Baillie, of the Royal Hospital, Greenwich; and Mr. Kendal the watchmaker, who accompanied the Astronomer-Royal to Greenwich, and saw the watch started and locked up in the box provided for it. The watch was then compared with the transit clock daily, and wound up in the presence of the officer of Greenwich Hospital. From May 5 to May 17 the watch was kept in a horizontal position with its face upwards; from May 18 to July 6 it was tried—first inclined at an angle of 20° to the horizon, with the face upwards, and the hours 12, 6, 3, and 9, highest successively; then in a vertical position, with the same hours highest in order; lastly, in a horizontal position with the face downwards. From July 16, 1766, to March 4, 1767, it was always kept in a horizontal position with its face upwards, lying upon the same cushion, and in the same box in which Mr. Harrison had kept it in the voyage to Barbadoes.

From the observed transits of the sun over the meridian, according to the time of the regulator of the Observatory, together with the attested comparisons of Mr. Harrison's watch with the transit clock, the watch was found too fast on several days as follows:

			h.	m.	s.
1766.	May 6	too fast	0	0	16·2
	,, 17	,,	0	3	51·8
	July 6	,,	0	14	14 0
	Aug. 6	,,	0	23	58 4
	Sept. 17	,,	0	32	15·6
	Oct 29	,,	0	42	20 9
	Dec. 10	,,	0	54	46 8
1767.	Jan. 21	,,	1	0	28 6
	March 4	,,	1	11	23·0

From May 6, which was the day after the watch arrived at the Royal Observatory, to March 4, 1767, there were six periods of six weeks each in which the watch was tried in a horizontal position; when the gaining in these several periods was as follows:

During the first 6 weeks it gained		13m	20s,	answering to	3°	20′	of longitude.
In the 2d period of 6 weeks (from Aug. 6 to Sept. 17)	,,	8	17	,,	2	4	,,
In the 3d period (from Sept. 17 to Oct. 29)	,,	10	5	,,	2	31	,,
In the 4th period (from Oct. 29 to Dec. 20)	,,	12	26	,,	3	6	,,
In the 5th period (from Dec. 20 to Jan. 21)	,,	5	42	,,	1	25	,,
In the 6th period (from Jan. 21 to Mar. 4)	,,	10	54	,,	2	43	,,

It was thence concluded that Mr. Harrison's watch could not be depended upon to keep the longitude within a West-India voyage of six weeks, nor to keep the longitude within half a degree for more than a fortnight; and that it must be kept in a place where the temperature was always some degrees above freezing.* (However, Harrison's watch, which was made by Mr. Kendal subsequently, succeeded so completely, that after it had been round the world with Captain Cook, in the years 1772-1775, the second 10,000*l.* was given to Harrison.)

In the Act of 12th Queen Anne, the comparison of chronometers was not mentioned in reference to the Observatory duties; but after this time they became a serious charge upon the Observatory, which, it must be admitted, is by far the best place to try chronometers: the excellence of the instruments, and the frequent observations of the heavenly bodies over the meridian, will always render the rate of going of the Observatory clock better known than can be expected of the clock in most other places.

After Mr. Harrison's watch was tried, some watches by Earnshaw, Mudge, and others, were rated and examined by the Astronomer-Royal.

At the Royal Observatory, Greenwich, there are frequently above 100 chronometers being rated, and there have been as many as 170 at one time. They are rated daily by two observers, the process being as follows. At a certain time every day two assistants in charge repair to the chronometer-room, where is a time-piece set to true time; one winds up each with its own key, and the second follows after some little time and verifies the fact that each is wound. One assistant then looks at each watch in succession, counting the beats of the clock whilst he compares the chronometer by the eye; and in the course of a few seconds he calls out the second shown by the chronometer when the clock is at a whole minute. This number is entered in a book by the other assistant, and so on till all the chronometers are compared. Then the assistants change places, the second comparing and the first writing down. From these daily comparisons the daily rates are deduced, by which the goodness of the watch is determined. The errors are of two classes—that of general bad workmanship, and that of over or under correction for temperature. In the room is an apparatus in which the watch may be continually kept at temperatures exceeding 100° by artificial heat; and outside the window of the room is an iron cage, in which they are subjected to low temperatures. The very great care taken with all chronometers sent to the Royal Observatory, as well as the perfect impartiality of the examination which each receives, afford encouragement to their manufacture, and are of the utmost importance to the safety and perfection of navigation.

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* In trying the merits of Harrison's chronometers, Dr. Maskelyne acquired that knowledge of the wants of nautical astronomy which afterwards led to the formation of the Nautical Almanac.

We have before us now the Report of the Astronomer-Royal on the Rates of Chronometers in the year 1854, in which the following are the successive weekly sums of the daily rates of the first there mentioned:

Week ending			secs.
Jan.	21,	loss in the week	2·2
,,	28	,,	4·0
Feb.	4	,,	1·1
,,	11	,,	5·0
,,	18	,,	4·9
,,	25	,,	5·5
Mar.	4	,,	6·0
,,	11	,,	6·0
,,	18	,,	1·5
,,	25	,,	4·5
Apr.	1	,,	4·0
,,	8	,,	1·5
,,	15,	gain in the week	0·4

Week ending			secs.
Apr.	22,	gain in the week	2·6
,,	29,	loss in the week	1·4
May	6	,,	2·1
,,	13	,,	3·0
,,	20	,,	5·1
,,	27	,,	3·3
June	3	,,	2·8
,,	10	,,	1·8
,,	17	,,	2·0
,,	24	,,	3·0
July	1	,,	2·5
,,	8	,,	1·2

Till February 4 the watch was exposed to the external air outside a north window; from February 5 to March 4 it was placed in the chamber of a stove heated by gas to a moderate temperature; and from April 29 to May 20 it was placed in the chamber when heated to a high temperature.

The advance in making chronometers since Harrison's celebrated watch was tried at the Royal Observatory, more than ninety years since, may be judged by comparing its rates with those above.

GEOMETRY OF SHELLS.

There is a mechanical uniformity observable in the description of shells of the same species which at once suggests the probability that the generating figure of each increases, and that the spiral chamber of each expands itself, according to some simple geometrical law common to all. To the determination of this law the operculum lends itself, in certain classes of shells, with remarkable facility. Continually enlarged by the animal, as the construction of its shell advances so as to fill up its mouth, the operculum measures the progressive widening of the spiral chamber by the progressive stages of its growth.

* * * * * * *

The animal, as he advances in the construction of his shell, increases continually his operculum, so as to adjust it to his mouth. He increases it, however, not by additions made at the same time all round its margin, but by additions made only on one side of it at once. One edge of the operculum thus remains unaltered as it is advanced into each new position, and placed in a newly-formed section of the chamber similar to the last but greater than it.

That the same edge which fitted a portion of the first less section should be capable of adjustment so as to fit a portion of the next similar but greater section, supposes a geometrical provision in the curved form of the chamber of great complication and difficulty. But God hath bestowed upon this humble architect the practical skill of the learned geometrician; and he makes this provision with admirable precision in that curvature of the logarithmic spiral which he gives to the section of the shell. This curvature obtaining, he has only to turn his operculum slightly round in its own place, as he advances it into each newly-formed portion of his chamber, to adapt one margin of it to a new and larger surface and a different curvature, leaving the space to be filled up by increasing the operculum wholly on the outer margin.

* * * * * * *

Why the Mollusks, who inhabit turbinated and discoid shells, should, in the progressive increase of their spiral dwellings, affect the peculiar law of the logarithmic spiral, is easily to be understood. Providence has subjected the instinct which shapes out each to a rigid uniformity of operation.—*Professor Mosely : Philos. Trans.* 1838.

HYDRAULIC THEORY OF SHELLS.

How beautifully is the wisdom of God developed in shaping out and moulding shells! and especially in the particular value of the constant angle which the spiral of each species of shell affects,—a value connected by a necessary relation with the economy of the material of each, and with its stability and the conditions of its buoyancy. Thus the shell of the *Nautilus Pompilius* has, hydrostatically, an A-statical surface. If placed with any portion of its surface upon the water, it will immediately turn over towards its smaller end, and rest only on its mouth. Those conversant with the theory of floating bodies will recognise in this an interesting property.—*Ibid.*

SERVICES OF SEA-SHELLS AND ANIMALCULES.

Dr. Maury is disposed to regard these beings as having much to do in maintaining the harmonies of creation, and the principles of the most admirable compensation in the system of oceanic circulation. "We may even regard them as regulators, to some extent, of climates in parts of the earth far removed from their presence. There is something suggestive both of the grand and the beautiful in the idea that while the insects of the sea are building up their coral islands in the perpetual summer of the tropics, they are also engaged in dispensing warmth to distant parts of the earth, and in mitigating the severe cold of the polar winter."

DEPTH OF THE PRIMEVAL SEAS.

Professor Forbes, in a communication to the Royal Society, states that not only the colour of the shells of existing mollusks ceases to be strongly marked at considerable depths, but also that well-defined patterns are, with very few and slight exceptions, presented only by testacea inhabiting the littoral, circumlittoral, and median zones. In the Mediterranean, only one in eighteen of the shells taken from below 100 fathoms exhibit any markings of colour, and even the few that do so are questionable inhabitants of those depths. Between 30 and 35 fathoms, the proportion of marked to plain shells is rather less than one in three; and between the margin and two fathoms the striped or mottled species exceed one-half of the total number. In our own seas, Professor Forbes observes that testacea taken from below 100 fathoms, even when they are individuals of species vividly striped or banded in shallower zones, are quite white or colourless. At between 60 and 80 fathoms, striping and banding are rarely presented by our shells, especially in the northern provinces; from 50 fathoms, shallow bands, colours, and patterns, are well marked. *The relation of these arrangements of colour to the degree of light penetrating the different zones of depth* is a subject well worthy of minute inquiry.

NATURAL WATER-PURIFIERS.

Mr. Warrington kept for a whole year twelve gallons of water in a state of admirably balanced purity by the following beautiful action:

In the tank, or aquarium, were two gold fish, six water-snails, and two or three specimens of that elegant aquatic plant *Valisperia sporalis*, which, before the introduction of the water-snails, by its decayed leaves caused a growth of slimy mucus, and made the water turbid and likely to destroy both plants and fish. But under the improved arrangement the slime, as fast as it was engendered, was consumed by the water-snails, which reproduced it in the shape of young snails, which furnished a succulent food to the fish. Meanwhile the *Valisperia* plants absorbed the carbonic acid exhaled by the respiration of their companions, fixing the carbon in their growing stems and luxuriant blossoms, and refreshing the oxygen (during sunshine in visible little streams) for the respiration of the snails and the fish. The spectacle of perfect equilibrium thus simply maintained between animal, vegetable, and inorganic activity, was strikingly beautiful; and such means might possibly hereafter be made available on a large scale for keeping tanked water sweet and clean.—*Quarterly Review*, 1850.

HOW TO IMITATE SEA-WATER.

The demand for Sea-water to supply the Marine Aquarium—now to be seen in so many houses—induced Mr. Gosse to attempt the manufacture of Sea-water, more especially as the constituents are well known. He accordingly took Scheveitzer's analysis of Sea-water for his guide. In one thousand grains of sea-water taken off Brighton, it gave: water, 964·744; chloride of sodium, 27·059; chloride of magnesium, 3·666; chloride of potassium, 9·755; bromide of magnesium, 0·29; sulphate of magnesia, 2·295; sulphate of lime, 1·407; carbonate of lime, 0·033: total, 999·998. Omitting the bromide of magnesium, the carbonate of lime, and the sulphate of lime, as being very small quantities, the component parts were reduced to common salt, 3½ oz.; Epsom salts, ¼ oz.; chloride of magnesium, 200 grains troy; chloride of potassium, 40 grains troy; and four quarts of water. Next day the mixture was filtered through a sponge into a glass jar, the bottom covered with shore-pebbles and fragments of stone and fronds of green sea-weed. A coating of green spores was soon deposited on the sides of the glass, and bubbles of oxygen were copiously thrown off every day under the excitement of the sun's light. In a week Mr. Gosse put in species of *Actinia Bowerbankia*, *Cellularia*, *Serpula*, &c. with some red sea-weeds; and the whole throve well.

VELOCITY OF IMPRESSIONS TRANSMITTED TO THE BRAIN.

Professor Helmholtz of Königsberg has, by the electro-magnetic method,* ascertained that the intelligence of an impression made upon the ends of the nerves in communication with the skin is transmitted to the brain with a velocity of about 195 feet per second. Arrived at the brain, about one-tenth of a second passes before the will is able to give the command to the nerves that certain muscles shall execute a certain motion, varying in persons and times. Finally, about $\frac{1}{100}$th of a second passes after the receipt of the command before the muscle is in activity. In all, therefore, from the excitation of the sensitive nerves till the moving of the muscle, 1¼ to $\frac{2}{10}$ths of a second are consumed. Intelligence from the great toe arrives about $\frac{1}{30}$th of a second later than from the ear or the face.

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* A slight electric shock is given to a man at a certain portion of the skin; and he is directed the moment he feels the stroke to make a certain motion, as quickly as he possibly can, with the hands or with the teeth, by which the time-measuring current is interrupted.

Thus we see that the differences of time in the nervous impressions, which we are accustomed to regard as simultaneous, lie near our perception. We are taught by astronomy that, on account of the time taken to propagate light, we now see what has occurred in the fixed stars years ago; and that, owing to the time required for the transmission of sound, we hear after we see is a matter of daily experience. Happily the distances to be traversed by our sensuous perceptions before they reach the brain are so short that we do not observe their influence, and are therefore unprejudiced in our practical interest. With an ordinary whale the case is perhaps more dubious; for in all probability the animal does not feel a wound near its tail until a second after it has been inflicted, and requires another second to send the command to the tail to defend itself.

PHOTOGRAPHS ON THE RETINA.

The late Rev. Dr. Scoresby explained with much minuteness and skill the varying phenomena which presented themselves to him after gazing intently for some time on strongly-illuminated objects,—as the sun, the moon, a red or orange or yellow wafer on a strongly-contrasted ground, or a dark object seen in a bright field. The doctor explained, upon removing the eyes from the object, the early appearance of the picture or image which had been thus "photographed on the Retina," with the photochromatic changes which the picture underwent while it still retained its general form and most strongly-marked features; also, how these pictures, when they had almost faded away, could at pleasure, and for a considerable time, be renewed by rapidly opening and shutting the eyes.

DIRECT EXPLORATION OF THE INTERIOR OF THE EYE.

Dr. S. Wood of Cincinnati states, that by means of a small double convex lens of short focus held near the eye,—that organ looking through it at a candle twelve or fifteen feet distant, —there will be perceived a large luminous disc, covered with dark and light spots and dark streaks, which, after a momentary confusion, will settle down into an unchanging picture, which picture is composed of the organs or internal parts of the eye. The eye is thus enabled to view its own internal organisation, to have a beautiful exhibition of the vessels of the cornea, of the distribution of the lachrymas secretions in the act of winking, and to see into the nature and cause of *muscæ volitantes.*

NATURE OF THE CANDLE-FLAME.

M. Volger has subjected this Flame to a new analysis.

He finds that the so-called *flame-bud*, a globular blue flaminule, is first produced at the summit of the wick: this is the result of the combustion of carbonic oxide, hydrogen, and carbon, and is surrounded by a reddish-violet halo, the *veil.* The increased heat now gives rise to the actual flame, which shoots forth from the expanding bud, and is then surrounded at its inferior portion only by the latter. The interior consists of a dark gaseous cone, containing the immediate products of the decomposition of the fatty acids, and surrounded by another dark hollow cone, the *inner cap.* Here we already meet with carbon and hydrogen, which have resulted from the process of decomposition; and we distinguish this cone from the inner one by its yielding soot. The *external cap* constitutes the most luminous portion of the flame, in which the hydrogen is consumed and the carbon rendered incandescent. The surrounding portion is but slightly luminous, deposits no soot, and in it the carbon and hydrogen are consumed.—*Liebig's Annual Report.*

HOW SOON A CORPSE DECAYS.

Mr. Lewis, of the General Board of Health, from his examination of the contents of nearly 100 coffins in the vaults and catacombs of London churches, concludes that the complete decomposition of a corpse, and its resolution into its ultimate elements, takes place in a leaden coffin with extreme slowness. In a wooden coffin the remains, with the exception of the bones, vanish in from two to five years. This period depends upon the quality of the wood, and the free access of air to the coffins. But in leaden coffins, 50, 60, 80, and even 100 years are required to accomplish this. "I have opened," says Mr. Lewis, "a coffin in which the corpse had been placed for nearly a century; and the ammoniacal gas formed dense white fumes when brought in contact with hydrochloric-acid gas, and was so powerful that the head could not remain in it for more than a few seconds at a time." To render the human body perfectly inert after death, it should be placed in a light wooden coffin, in a pervious soil, from five to eight feet deep.

MUSKET-BALLS FOUND IN IVORY.

The Ceylon sportsman, in shooting elephants, aims at a spot just above the proboscis. If he fires a little too low, the ball passes into the tusk-socket, causing great pain to the animal, but not endangering its life; and it is immediately surrounded by osteo-dentine. It has often been a matter of wonder how such bodies should become completely imbedded in the substance of the tusk, sometimes without any visible aperture; or how leaden bullets become lodged in the solid centre of a very large tusk without having been flattened, as they are found by the ivory-turner.

The explanation is as follows: A musket-ball aimed at the head of an elephant may penetrate the thin bony socket and the thinner ivory parietes of the wide conical pulp-cavity occupying the inserted base of the tusk; if the projectile force be there spent, the ball will gravitate to the opposite and lower side of the pulp-cavity. The pulp becomes inflamed, irregular calcification ensues, and osteo-dentine is formed around the ball. The pulp then resumes its healthy state and functions, and coats the osteo-dentine enclosing the ball, together with the root of the conical cavity into which the mass projects, with layers of normal ivory. The hole formed by the ball is soon replaced, and filled up by osteo-dentine, and coated with cement. Meanwhile, by the continued progress of growth, the enclosed ball is pushed forward to the middle of the solid tusk; or if the elephant be young, the ball may be carried forward by growth and wear of the tusk until its base has become the apex, and become finally exposed and discharged by the continual abrasion to which the apex of the tusk is subjected.—*Professor Owen.*

NATURE OF THE SUN.

To the article at pp. 59-60 should be added the result obtained by Dr. Woods of Parsonstown, and communicated to the *Philosophical Magazine* for July 1854. Dr. Woods, from photographic experiment, has no doubt that the light from the centre of flame acts more energetically than that from the edge on a surface capable of receiving its impression; and that light from a luminous solid body acts equally powerfully from its centre or its edges: wherefore Dr. Woods concludes that, as the sun affects a sensitive plate similarly with flame, it is probable its light-producing portion is of a similar nature.

Note to "IS THE HEAT OF THE SUN DECREASING?" *at page* 65.—Dr. Vaughan of Cincinnati has stated to the British Association: "From a comparison of the relative intensity of solar, lunar, and artificial light, as determined by Euler and Wollaston, it appears that the rays of the sun have an illuminating power equal to that of 14,000 candles at a distance of one foot, or of 3500,000000,000000,000000,000000 candles at a distance of 95,000,000 miles. It follows that the amount of light which flows from the solar orb could be scarcely produced by the daily combustion of 200 globes of tallow, each equal to the earth in magnitude. A sphere of combustible matter much larger than the sun itself should be consumed every ten years in maintaining its wonderful brilliancy; and its atmosphere, if pure oxygen, would be expended before a few days in supporting so great a conflagration. An illumination on so vast a scale could be kept up only by the inexhaustible magazine of ether disseminated through space, and ever ready to manifest its luciferous properties on large spheres, whose attraction renders it sufficiently dense for the play of chemical affinity. Accordingly suns derive the power of shedding perpetual light, not from their chemical constitution, but from their immense mass and their superior attractive power."

PLANETS.

Name.	Date of Discovery.	Discoverer.	Place of Discovery.	No. discovered by each astronomer.
Mercury Mars, Venus, Jupiter, Earth, Saturn,	Known to the ancients.	....	....	—
Uranus	1781, March 13.	W. Herschel	Bath	—
*Neptune	1846, Sept. 23.	Galle	Berlin	—
1 Ceres	1801, Jan. 1	Piazzi	Palermo	1
2 Pallas	1802, March 28.	Olbers	Bremen	1
3 Juno	1804, Sept. 1	Harding	Lilienthal	1
4 Vesta	1807, March 29.	Olbers	Bremen	2
5 Astræa	1845, Dec. 8	Encke	Driesen	1
6 Hebe	1847, July 1	Encke	Driesen	2
7 Iris	1847, August 13.	Hind	London	1
8 Flora	1847, Oct. 18	Hind	London	2
9 Metis	1848, April 25	Graham	Markree	1
10 Hygeia	1849, April 12	Gasperis	Naples	1
11 Parthenope	1850, May 11	Gasperis	Naples	2
12 Victoria	1850, Sept. 13	Hind	London	3
13 Egeria	1850, Nov. 2	Gasperis	Naples	3
14 Irene	1851, May 19	Hind	London	4
15 Eunomia	1851, July 29	Gasperis	Naples	4
16 Psyche	1852, March 17.	Gasperis	Naples	5
17 Thetis	1852, April 17	Luther	Bilk	1
18 Melpomene	1852, June 24	Hind	London	5
19 Fortuna	1852, August 22.	Hind	London	6
20 Massilia	1852, Sept. 19	Gasperis	Naples	6
21 Lutetia	1852, Nov. 15	Goldschmidt	Paris	1
22 Calliope	1852, Nov. 16	Hind	London	7
23 Thalia	1852, Dec. 15	Hind	London	8
24 Themis	1853, April 5	Gasperis	Naples	7
25 Phocea	1853, April 6	Chacornac	Marseilles	1
26 Proserpine	1853, May 5	Luther	Bilk	2
27 Euterpe	1853, Nov. 8	Hind	London	9
28 Bellona	1854, March 1	Luther	Bilk	3
29 Amphitrite	1854, March 1	Marth	London	1
30 Urania	1854, July 22	Hind	London	10
31 Euphrosyne,	1854, Sept. 1	Furguson	Washington.	1
32 Pomona	1854, Oct. 26	Goldschmidt	Paris	2
33 Polyhymnia	1854, Oct. 28	Chacornac	Paris	2
34 Circe	1855, April 6	Chacornac	Paris	3
35 Leucothea	1855, April 19	Luther	Bilk	4
36 Atalante	1855, Oct. 5	Goldschmidt	Paris.	3
37 Fides	1855, Oct. 5	Luther.	Bilk	5
38 Leda	1856, Jan. 12	Chacornac	Paris	4
39 Lætitia	1856, Feb. 8	Chacornac	Paris	5
40 Harmonia	1856, March 31.	Goldschmidt	Paris	4
41 Daphne	1856, May 22	Goldschmidt	Paris.	5
42 Isis	1856, May 23	Pogson	Oxford	1
43 Ariadne	1857, April 15	Pogson	Oxford	2
44 Nysa	1857, May 27	Goldschmidt	Paris	6
45 Eugenia	1857, June 28	Goldschmidt	Paris	7
46 Hestia	1857, August 16.	Pogson	Oxford	3
47 Aglaia	1857, Sept. 15	Luther	Bilk	6
48 Doris	1857, Sept 19	Goldschmidt	Paris	8
49 Pales	1857, Sept. 19	Goldschmidt	Paris	9
50 Virginia	1857, Oct. 4	Furguson	Washington.	2
51 Nemausa	1858, Jan. 22	Laurent	Nismes	1
52 Europa	1858, Feb. 6	Goldschmidt	Paris	10
53 Calypso	1858, April 8	Luther	Bilk	7
54 Alexandra	1858, Sept. 11	Goldschmidt	Paris	11
55 (Not named).	1858, Sept. 11	Searle	Albany	1

* Through the calculations of M. Le Verrier.

THE COMET OF DONATI.

While this sheet was passing through the press, the attention of astronomers, and of the public generally, was drawn to the fact of the above Comet passing (on Oct. 18) within nine millions of miles of the planet Venus, or less than $\frac{9}{100}$ths of the earth's distance from the Sun. "And (says Mr. Hind, the astronomer), it is obvious that if the comet had reached its least distance from the sun a few days earlier than it has done, the planet might have passed through it; and I am very far from thinking that close proximity to a comet of this description would be unattended with danger. The inhabitants of Venus will witness a cometary spectacle far superior to that which has recently attracted so much attention here, inasmuch as the tail will doubtless appear twice as long from that planet as from the earth, and the nucleus proportionally more brilliant."

This Comet was first discovered by Dr. G. B. Donati, astronomer at the Museum of Florence, on the evening of the 2d of June, in right ascension 141° 18′, and north declination 23° 47′, corresponding to a position near the star Leonis. Previous to this date we had no knowledge of its existence, and therefore it was not a predicted comet; neither is it the one last observed in 1556. At the date of discovery it was distant from the earth 228,000,000 of miles, and was an excessively faint object in the largest telescopes.

The tail, from October 2 to 16, when the comet was most conspicuous, appears to have maintained an average length of at least 40,000,000 miles, subtending an angle varying from 30° to 40°. The dark line or space down the centre, frequently remarked in other great comets, was a striking characteristic in that of Donati. The nucleus, though small, was intensely brilliant in powerful instruments, and for some time bore high magnifiers to much greater advantage than is usual with these objects. In several respects this comet resembled the famous ones of 1744, 1680, and 1811, particularly as regards the signs of violent agitation going on in the vicinity of the nucleus, such as the appearance of luminous jets, spiral offshoots, &c., which rapidly emanated from the planetary point and as quickly lost themselves in the general nebulosity of the head.

On the 5th Oct. the most casual observer had an opportunity of satisfying himself as to the accuracy of the mathematical theory of the motions of comets in the near approach of the nucleus of Donati's to Arcturus, the principal star in the constellation Bootes. The circumstance of the appulse was very nearly as predicted by Mr. Hind.

The comet, according to the investigations by M. Loewy, of the Observatory of Vienna, arrived at its least distance from the sun a few minutes after eleven o'clock on the morning of the 30th of September; its longitude, as seen from the sun at this time, being 36° 13′, and its distance from him 55,000,000 miles. The longer diameter of its orbit is 184 times that of the earth's, or 35,100,000,000 miles; yet this is considerably less than $\frac{1}{1000}$th of the distance of the nearest fixed star. As an illustration, let any one take a half-sheet of note-paper, and marking a circle with a sixpence in one corner of it, describe therein our solar system, drawing the orbits of the earth and the inferior planets as small as he can by the aid of a magnifying-glass. If the circumference of the sixpence stands for the orbit of Neptune, then an oval filling the page will fairly represent the orbit of Donati's comet; and if the paper be laid upon the pavement under the west door of St. Paul's Cathedral, London, the length of that edifice will inadequately represent the distance of the nearest fixed star. The time of revolution resulting from Mr. Loewy's calculations is 2495 years, which is about 500 years less than that of the comet of 1811 during the period it was visible from the earth.

That the comet should take more than 2000 years to travel round the above page of note-paper is explained by its great diminution of speed as it recedes from the sun. At its perihelion it travelled at the rate of 127,000 miles an hour, or more than twice as fast as the earth, whose motion is about 1000 miles a minute. At its aphelion, however, or its greatest distance from the sun, the comet is a very slow body, sailing at the rate of 480 miles an hour, or only eight times the speed of a railway express. At this pace, were it to travel onward in a straight line, the lapse of a million of years would find it still travelling half way between our sun and the nearest fixed star.

As this comet last visited us between 2000 and 2495 years since, we know that its appearance was at an interesting period of the world's history. It might have terrified the Athenians into accepting the bloody code of Draco. It might have announced the destruction of Nineveh, or of Babylon, or the capture of Jerusalem by Nebuchadnezzar. It might have been seen by the expedition which sailed round Africa in the reign of Pharaoh Necho. It might have given interest to the foundation of the Pythian games. Within the probable range of its last visitation are comprehended the whole of the great events of the history of Greece; and among the spectators of the comet may have been the so-called sages of Greece and even the prophets of Holy Writ: Thales might have attempted to calculate its return, and Jeremiah might have tried to read its warning. —*Abridged from a Communication from Mr. Hind to the Times, and from a Leader in that Journal.*

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THE ALCHEMIST.

FROM A PICTURE PAINTED BY TENIERS. (See p. vii.)

Things not generally Known.

CURIOSITIES OF SCIENCE:

Second Series.

A BOOK FOR OLD AND YOUNG.

By JOHN TIMBS, F.S.A.,

AUTHOR OF "THINGS NOT GENERALLY KNOWN;" AND EDITOR OF "THE YEAR-BOOK OF FACTS."

Decomposition of Water under the Oxyhydrogen Gas Microscope.
(See page vii.)

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GENTLE READER,

This Second Series of "CURIOSITIES OF SCIENCE" completes the anecdotic illustrations commenced in the First Series: at the same time it forms the Sixth Volume of "THINGS NOT GENERALLY KNOWN FAMILIARLY EXPLAINED," and concludes that design.

The present volume is devoted, in the main, to CHEMISTRY, its Students and Professors. In the plan, the object has not been systematic tuition; although the sequence of subject has been kept in view, so far as could be appropriately realised. The early portion of the volume is retrospective and historical, illustrating the profession of ALCHEMY in brief biographical notices of its practitioners; then tracing the transition from Alchemy to Modern Chemistry, and attempting to distinguish the early Chemists from the Alchemists—the real from the ideal—the founders of a great science from the charlatans of low artifice and imposture. In this section of the work an attempt has been made to sketch the fates and fortunes of the Alchemists, briefly and without recourse to the *shibboleth* of their art; special regard being had for the individual characteristics of the practitioners, their portraitures and habits and true histories.

Under "MODERN CHEMISTRY" and "GENERAL SCIENCE" striking Facts and Phenomena are popularly recorded,—often by way of anecdote,—keeping in view the recreative object of this little volume, which, in accordance with others of the Series of which it forms a portion, seeks to impart information and entertainment in the same moment, respecting "THINGS NOT GENERALLY KNOWN."

In presenting you with this volume, I recur with grateful feelings to the large share of public favour which continues to be extended to the entire Work. Its main idea—that of seizing upon topics imperfectly understood, and conveying, in an attractive form, information beyond commonplace—has been purloined and parodied in a legion of shapes, and often with such disfigurement as gipsies inflict upon stolen children. Nevertheless, the unflagging interest taken by the reading public in the portion of "THINGS NOT GENERALLY KNOWN" already published, leads me to hope that the like favour may be extended to the present volume.

I. T.

June 1860.

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The Frontispiece.

THE ALCHEMIST, PAINTED BY TENIERS.

This aged experimentalist in "the more sublime and occult part of chemistry" is the principal figure in a picture by the younger Teniers, from the Orleans Gallery. It is characteristic of the attention paid to the Alchemists and their labours in the present work; and when it is remembered how much Chemists owe to the Alchemists, the details of their art and mystery may fairly be numbered among the "Curiosities of Science." (See pp. 1-47.)

The Vignette.

DECOMPOSITION OF WATER UNDER THE OXYHYDROGEN GAS MICROSCOPE.

The Decomposition of Water by chemical action presents a very curious appearance under the Gas Microscope: it was exhibited at the Royal Gallery of Practical Science, Strand; at the Polytechnic Institution in Regent Street; and other establishments of this class, which have so long gratified a healthy taste amongst the people for the marvels of modern science. The process is thus described by Mr. Edward M. Clarke, in his *Directions for using Philosophical Apparatus in Private Research and Public Exhibitions.* The Author will be remembered as a manufacturer of Mathematical, Philosophical, and Optical Apparatus, in the Strand. He supplied many of the instruments at the Adelaide Gallery, at the Colosseum in the Regent's Park, and at the Polytechnic Institution; and to Mr. Clarke's untiring industry was mainly due the establishment of the Panopticon in Leicester Square; an enterprise which, unfortunately for the public as well as the proprietors, did not prove commercially successful. It is, however, due to a man of Mr. Clarke's energetic character to state these facts, that the exertions of one who laboured so zealously for the public gratification may be rightly appreciated. In England Scientific Exhibitions are left to the chances of ordinary speculation; and little is done by the State in this great country of the Steam-engine to gratify the desires of the people for scientific study or recreation, unless the scheme be recommended by some prospects of patronage and personal influence. If, however, it were rightly considered how much the scientific colour of public amusements is calculated to benefit the intelligence of the people, more attention would be paid to the subject.

The Decomposition of Water is effected by the adaptation of a glass trough to the microscope (introduced horizontally in the manner of a slider), containing diluted sulphuric acid, similar to that employed in the preparation of hydrogen gas. On a few pieces of fresh-broken zinc being dropped into the diluted acid, decomposition of the water instantly commences. Its oxygen gas combines unperceived with the zinc, which then dissolves gradually in the sulphuric acid; while the hydrogen gas, set free at the same instant, rapidly rises in bubbles through the liquid, and escapes at the surface. These bubbles, magnified, present a most extraordinary appearance, forming a series of whitish luminous globules, descending in the fluid (for every thing appears reversed in the microscopic exhibitions) from an opaque surface, and swelling enormously as they struggle, under the trebly expansive powers of heat, combination, and lessening pressure.

By means of the glass troughs, made without joinings in moulds, Mr. Clarke was enabled to adapt with fine effect Sturgeon's interesting experiment of the Decomposition of Water by a voltaic circuit arising from the action of Platinum on amalgamated Zinc, in the following manner. The trough, containing diluted sulphuric acid, as in the previous exhibition, is introduced horizontally, and held fast in its place like a slider by the internal spring. A piece of amalgamated zinc is then dropped into the liquid, but no action takes place. A piece of platinum wire is then thrust into the liquid, but if kept apart from the amalgamated zinc, still no action is apparent. The moment, however, that the wire is brought into contact with the amalgamated lump, pearly bubbles of gas are seen to form on all parts of the platinum. In the engraving, Z is the lump of amalgamated zinc seen in dark profile on the illuminated disk, and the equally dark serpentine line in contact with it is the platinum wire. It will be observed, that notwithstanding the platinum wire is covered with gas, not a single bubble is given off from the amalgam. If the wire is lifted from its contact with the latter, all chemical action and formation of bubbles instantly cease. If again allowed to touch the amalgamated zinc, the gas is generated as at first.

Other modes of the Decomposition of Water, with details of the celebrated experiment of 1781, will be found at pp. 77-79.

CURIOSITIES OF SCIENCE.

(SECOND SERIES.)

Alchemy and Chemistry.

WHAT THE CHEMISTS OWE TO THE ALCHEMISTS.

Inestimable benefits have accrued to mankind from the ancient practice of an art which is now considered, but with some injustice, to have been a low delusion and imposture. "Look into the books of the alchemists, and some idea may be formed of the effects of experiments. It is true, these persons were guided by false views; yet they made most useful researches," and thus laid the foundation of experimental science and modern Chemistry.

Chemistry has been traced to the cradle of civilisation; the name itself being derived by Cuvier from the word *Chim*, which was the ancient name of Egypt. He states that minerals were known to the Egyptians "not only by their external characters, but also by what we at the present day call their *chemical characters.*"

Suidas derives the name from the Greek *chemeia*, "the making of silver or gold," or what is now more generally known by the name of Alchemy. Suidas adds that Diocletian burnt all the ancient books in Egypt on chemistry, in order that the Egyptians might no longer be able to acquire wealth by the practice of this art, and thus be encouraged to resist the Romans. This accords with Cuvier's idea that *chemeia* is an Egyptian word; and its resemblance to Cham or Chem, the genuine name of the country, is a confirmation of the supposition as to its origin. The word indicates literally Egyptian art, the art of the black land. The inscription on the Rosetta stone has the word *Chim.*

Among the chemical knowledge of the Romans under the Empire, we find a few experiments by Dioscorides, and the technical art of collecting fluids by the process of distillation.

This famous Greek wrote on Materia Medica,—the title of his principal work,—and few books have ever enjoyed such long and universal celebrity. For sixteen centuries and more this work was referred to as the fountain-head of all authority by every body who studied either botany or the mere virtues of plants. Dioscorides collected his materials for this work by travelling through Greece, Italy, Asia Minor, and some parts of Gaul, gathering plants in his journey, and acquainting himself with their properties real or reputed. He likewise assembled the opinions current in his day concerning the medical plants brought from countries not visited by himself, especially from India, which at that time furnished many drugs to the western markets. From such materials he compiled his *Materia Medica*, wherein between 500 and 600 medical plants are named and briefly described. With this work, up to the commencement of the seventeenth century, the whole of academical or private study on such subjects was begun and ended; and it was only when the rapidly increasing numbers of new plants, and the general advance in all branches of physical knowledge, compelled people to admit that the vegetable kingdom might contain more things than were dreamt of by Dioscorides, that his authority ceased to be acknowledged. It should be added, that although his work shows the amount of Materia Medica knowledge in his day, it must not be admitted as evidence of the state of botany at the same period; for Dioscorides has no pretension to be ranked among the botanists of antiquity, considering that the writings of Theophrastus, four centuries earlier, show that botany had even at that time begun to be cultivated as a science distinct from the art of the herbalist.

But Chemistry cannot be said to have begun until men learnt to obtain mineral acids, and to employ them for the solution and liberation of substances; and it is on this account that the distillation of sea-water described by Alexander of Aphrodisia,* under Caracalla, is so worthy of notice. It designates the path by which man gradually arrived at a knowledge of the heterogeneous nature of substances, their chemical composition, and their mutual affinities. —*Humboldt's Cosmos*, vol. ii.

EGYPTIAN ALCHEMY.

The late Sir William Drummond wrote in the *Classical Journal* an elaborate defence of Egyptian Alchemy. He first asserts that the ancient Egyptians could not have possessed gold by any ordinary modes, *inasmuch as they had no mines*, and were not addicted to commerce; yet they constructed vast buildings and public works—such as the Labyrinth, the Lake Mœris, the Pyramids, and the tomb of Osymandias, the golden circle in which Sir William values at 14,000,000*l.* sterling. He quotes Herodotus' statement, that the charge for onions and garlic furnished to the labourers on the Pyramids amounted to 1600 silver talents, *i. e.* about 600,000*l.* sterling. "Gold," observes he, "was so plentiful that the hunter formed his weapons and the labourer his tools of this precious metal." After noticing the great hatred with which the Egyptians regarded Cambyses and his Persian followers, he states that the priests, who alone possessed the power of making gold, concealed it till the accession of the House of Lagus, when they again made known their scientific knowledge. Such are a few of the assumed facts upon which a defence of Alchemy is founded, and such are the arguments by which it is supported. But, first, *the inhabitants of Egypt had gold-mines*, and vestiges of them exist to this day;* next, many learned men deny that the Lake Mœris ever existed, and that the circle or planisphere of gold over the tomb of Osymandias, not being mentioned by Herodotus, is of very questionable existence; nor does he explain how Cheops raised the money to build the great pyramid; and the amount of the charges for food, clothing, tools, and refreshments is ridiculously small; while Herodotus shows that the Egyptian monarchs suffered from an exhausted exchequer, which they need not have done had they made their own gold. Such are the arguments by which Alchemy has been *historically* supported. They are not much better than Borrachius's syllogism—that because the ancient Egyptians hatched eggs in ovens, they therefore possessed the Philosopher's Stone and the Universal Medicine.—Abridged from the Rev. Mr. Christmas's *Cradle of the Twin Giants*, vol. ii.

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* Although Alexander of Aphrodisia, properly speaking, gives only a circumstantial description of distillation from sea-water, he draws attention to the fact that wine may likewise be distilled. This statement is the more remarkable because Aristotle (*Meteorol.* ii. 3, p. 358, Bekker) had advanced the erroneous opinion, that in natural evaporation fresh water only rose from wine as from the salt water of the sea.

METALS KNOWN TO THE ANCIENTS.

Gold was the	*Sun*, and was represented thus			☉
Silver ,,	*Moon*	,,	,,	☽
Mercury ,,	*Mercury*	,,	,,	☿
Copper ,,	*Venus*	,,	,,	♀
Iron ,,	*Mars*	,,	,,	♂
Tin ,,	*Jupiter*	,,	,,	♃
Lead ,,	*Saturn*	,,	,,	♄

The names of planets were chosen from being supposed to have some mysterious relation; and each metal was denoted by a particular symbol, representing both the metal and the planet. This planetary designation, as adopted by the alchemists, forms the basis of some chemical and medical terms now in use. Thus we have *Lunar* Caustic, or fused nitrate of silver; *Martial* pyrites, or native sulphuret of iron; *Mercury* is even now as much a term as quicksilver; and *Saturnine* paralysis is paralysis caused by salts of lead.—*Faraday's Lecture:* Note by Scoffern.

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* Sir Gardner Wilkinson says, the gold-mines of Egypt, though mentioned by Agatharcides and later writers, and worked even by the Arabian caliphs, long remained unknown; and their position was only ascertained a few years since by M. Lenant and M. Bonomi, who found Cufic inscriptions showing that the mines were worked in the years 339 A.H. (931 A.D.) and 378 A.H. (989 A.D.). The matrix is quartz; and so diligently did the Egyptians work for the metal, that the veins have been picked out of the fissures and broken into small fragments.

The above explains the association of Astrology and Alchemy. An Oxford Professor has remarked: "It is not a little remarkable how frequently the discoveries of modern days have served to redeem the fancies of mediæval times from the charge of absurdity. If tho direction of a bit of steel suspended near the earth can, as Colonol Sabine has proved, be influenced by the position of a body like the moon, situated at the distance from it of more than 200,000 miles, who shall say that there was any thing preposterously extravagant in the conception, however little support it may receive from experience, in the influence ascribed to the stars over the destinies of men by the astrologers of olden time?"—*Dr. Daubeny, F.R.S.*

THE ARABS.—GEBER.

Hitherto we have only referred in part to the origin of the name *Alchemy*, from the Greek; whereas, the first syllable, *al*, denotes the probability of the Arabic origin of the art. Dr. Thomson supposes it to have originated with the Arabs when they began to turn their attention to medicine, after the establishment of the Caliphs; so that if it had been previously cultivated by the Greeks, as there is some reason to suppose, it was taken up by the Arabians, and reduced by them into regular form and order.

The Arabs, we know, exercised a most powerful influence on general natural physics by the advances of chemistry, a science for which this race created a new era. It must be admitted that alchemistic and new-Platonic fancies were as much blended with chemistry as astrology with astronomy. The requirements of pharmacy, and the equally urgent demands of the technical arts, led to discoveries which were promoted, sometimes designedly and sometimes by a happy accident depending upon alchemistical investigation into the study of metallurgy.

Geber, the Arab physician, who lived in the seventh century, is one of the earliest alchemists whose works are extant; but their genuineness is doubted. He implicitly adopts the principles which lie at the bottom of alchemy; but he does not attempt to make gold artificially, nor admit the possibility of converting the baser metals into gold. Geber also treats of the Universal Medicine, Tincture, Elixir, and the Philosopher's Stone. Dr. Johnson supposes that the word *Gibberish*, anciently written *Geberish*, was originally applied to the language of Geber and his tribe, and quotations from his works justify the etymology. Geber was an alchemist in the most comprehensive sense of the word, and his works abound with the absurd and mystical phrases of the art; but his *chemical* labours were directed to the improvement of medicine; he describes and depicts furnaces, crucibles, alembics, and other useful chemical apparatus, of which he is thought to have been the inventor; and he treats of distillation, sublimation, calcination, and various other chemical operations. To him we also owe the first mention of corrosive sublimate, the red oxide of mercury, nitric acid, and the nitrate of silver. His sun of "perfection," or instructions to students to aid them in the laborious search for the Stone and Elixir, has been translated into most of the languages of Europe: an English translation, by a great enthusiast in alchemy, one Richard Russell, was published in London in 1686, the preface of which is dated from Newmarket.

Thus the preparation of nitric acid by Geber dates back more than 500 years before Albertus Magnus and Raymond Lully, and almost 700 years before Basil Valentine; although the discovery of these decomposing (dissolving) acids was long ascribed to the three last experimentalists.

Razes gives the rules for the vinous fermentation of amylum and sugar, and for the distillation of *alcohol*, or *al Kahala*, which in Arabic means the sulphuret or common ore of antimony used by the Arabian women to blacken their eyebrows. According to the dictionary of the Spanish Academy, the alchemists were in the habit of selling this mineral along with ardent spirit, believing that a highly concentrated spirit was the result: hence the word Alcohol, a corruption of *al Kahala*.

HERMES TRISMEGISTUS.

Hermes Trismegistus is generally mentioned as one of the earliest alchemists: from him alchemy has been called the *Hermetic art*; and the word *hermetic*, still in common use, is derived from Hermes, and employed to denote perfectly close, so that no air can escape; but the ancient *hermetic seal* was formed by fusing the mouth or extremity of a vessel so as to close it entirely. Still the writings bearing the name of Hermes are undoubtedly spurious. With the view of gaining credence for alchemy, it was also called the Egyptian science; but, says Cuvier, the art of transmuting metals was a mere reverie of the middle ages, utterly unknown to antiquity: "the pretended books of Hermes are evidently supposititious, and were written by the Greeks of the lower Empire."

ALBERTUS MAGNUS.

Passing over less celebrated alchemists, we come to Albertus Magnus, a German, born in 1282. In his treatise *De Alchemâi*, he describes all chemical substances known in his time; he was well acquainted with chemical apparatus, and with the method of purifying the precious metals. He imagined that the metals were composed of mercury and sulphur, and accounts for the diversity of them by the difference in the proportion of their constituents and their purity. His writings are in general plain and intelligible; Thomas Aquinas is believed to have been the pupil of Albert. He wrote three works on alchemy; and the word *Amalgam*,* signifying a compound of mercury and another metal, occurs, and probably for the first time, in his writings, which contain also some other terms still used in chemistry.

RAYMOND LULLY.

Nearly half a century earlier, in 1234, was born, at Majorca, Raymond Lully, stated to have been the scholar and the friend of Roger Bacon. His reputation as an alchemist was very high: he was well acquainted with chemical compounds, and their action upon each other; he obtained nitric acid by distilling a mixture of nitre and green vitriol, observed its power of acting upon metals generally, and of dissolving gold when mixed with sal ammoniac. He appears to have taken Geber for his model late in life.

Lully's history is peculiarly interesting to the English reader from his biographers' stating that, upon the invitation of the sovereign, he settled in England, and in apartments assigned for his use in the Tower of London refined much gold; superintended the coinage of *rose-nobles*, and made gold out of iron, quicksilver, lead, and pewter, to the amount of six millions! That he came to England is attested in a work attributed to him on the Transmutation of Metals, though it is not clear whether he came at the intercession of Edward I. or II. That he was employed in refining gold and in coining, "in the chamber of St. Katherine," in the Tower, is reasonable enough; and rumour may have assigned to him the possession of the grand secret, which he did not contradict. He left many learned works, among which were treatises on physics, astronomy, medicine, and chemistry.

From this it is inferred that Lully lived in the Hospital of St. Katherine, so as to be near the Mint-works in the Tower. In the *rose-noble* the image of the sun, surmounted by the mystical flower, as well as the inscription on the obverse, "Jesus autem transiens per medium illorum ibat," must, according to the adepts, be considered as denoting the art which formed the precious metal. Lully was hospitably received by Abbot Cremer in the Abbey at Westminster; and many years after his decease, a little chest, filled with the powder of transmutation, was found in the cell which he had inhabited. Lully had refused to make any more money for the king, who had broken the condition—that it should be employed in making war upon infidels and unbelievers; whereas Edward had spent the supplies in his wars with the Scots. In the dispute which followed, the king waxed wroth, and, as Ashmole relates, confined Lully in the Tower, where he remained for a long time, and at length escaped in the disguise of a leper.

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* *Amalgam*, a compound of two or more metals, of which one is always mercury; which circumstance distinguishes an *amalgam* from a mere *alloy*.

THE PHILOSOPHER'S STONE.

In the thirteenth century arose for the first time the idea that the Philosopher's Stone had the power of healing disease and of restoring youth. This idea was developed from the opinion that the vital process was nothing else than a chemical process. With the Philosopher's Stone it was possible to heal metals of their maladies, to render them healthy, and convert them into gold; and the idea that it must have a like effect upon the human body naturally suggested itself. Hollandus, in his *Opus Saturni*, says of the healing virtues of the Stone: "A portion of it, the size of a grain of wheat, should be laid in wine, and then given to the patient. The action of the wine will penetrate to the heart, and spread itself through all the juices. The patient will sweat, and therefore become not more weary, but even stronger and more cheerful. This dose should be repeated every ninth day, when the patient shall think he is no longer a man, but a spirit. He shall feel as if he were nine days in Paradise, and living on its fruits." Solomon Trimousin maintains that, when an old man, he renewed his youth by means of a grain of the Philosopher's Stone! His yellow wrinkles became smooth and white, his cheeks rosy, his gray hairs black, his back, bowed with age, became erect. He restored, as he asserts, perfect youthfulness to ladies ninety years of age!

This was, however, the abuse of the preëminence which the scientific men of that early age had obtained. "The expectations of the alchemists to find a Universal Medicine were not altogether irrational and useless. The success of the Arabian physicians in the use of mercurial preparations naturally led to the belief that other medicines still more general in their healing powers might yet be brought to light; and we have no doubt that many important discoveries were the result of such over-strained expectations; but when the alchemists pretended to have obtained such a medicine, and to have conferred longevity by administering it, they did equal violence to reason and to truth."—*Sir D. Brewster.*

In all metals (says Liebig), according to the creed of the alchemists, there is contained a principle which gives to them the metallic character. This is *the mercury of the adepts.* To increase the proportion of this principle in the baser metals, is to ennoble them. If we extract this metallic principle from any body or metal, if we increase its power by refining it, and thus produce the quintessence of all *metallicity* (to coin a word), we have the Stone, which, when made to act on base or unripe metals, matures and ennobles them. The mode of action of the Philosopher's Stone was considered by many as analogous to that of a ferment. "Does not yeast change the juice of plants or a solution of sugar, by a new arrangement of their particles, into the youth-giving and invigorating water of life (*aqua vitæ*, alcohol)? Does it not effect the expulsion of all impurities? Does not a ferment (sour dough) convert flour into nourishing bread?"—*George Rippel*, 15th century.

In its utmost perfection, as the *universale*, one part, according to Roger Bacon, sufficed to transmute a million parts, according to Raymond Lully, a thousand billions of parts, of a base metal into gold. According to Basil Valentine, the power of the Philosopher's Stone extends only to seventy parts; and Dr Price, the last alchemist and gold-maker of the eighteenth century, describes it as transmuting only from thirty to sixty parts of base metal.—*Liebig's Familiar Letters on Chemistry.*

The preparation of the Philosopher's Stone is thus briefly given by Isaacus Hollandus: From the adamite earth—virgin earth—to be found every where, but on certain conditions known to the initiated alone, "the philosopher obtains, first, the mercury of the adepts, which differs from the ordinary quicksilver, and is the quintessence—the first condition—of the creation or procreation of all metals. To this is added philosophical gold, and the mixture is left for a long time in an incubatory, or brooding furnace, which must have the form of an egg. There is thus obtained a black substance, the raven's head, or *caput corvi*, which, after long exposure to heat, is converted into a white body. This is the white swan, *cygnus albus*. After this has been long and more fiercely heated, it becomes yellow, and finally bright red, and now the great work is consummated."

Yet, although the existence of the Stone was regarded for centuries as an established truth, no one possessed it; each adept only maintaining that it was in the possession of another.

ROGER BACON.

One of his contemporaries, Roger Bacon, possessed a much greater mind than Lully; and although he believed in the production of the Philosopher's Stone, and wrote a Mirror of Alchemy, he made its study secondary to other pursuits after universal knowledge: indeed, his astrology and alchemy are usually called the two great blots on his character. He is the "Friar Bacon" of the story-books; and the circumstance of his being a Franciscan destined him to many years' persecution on account of his discoveries during his lifetime, and to the low reputation of being an impostor for centuries after his death. But he was not only the greatest man of his time, but was many centuries in advance of his age. He was born about 1214, and was educated at that seat of early science, Merton College, Oxford. "Neglecting common opinion," he studied physiology, mathematics, and chemistry; spent ten years on geometry, and ten others on the cognate sciences; while he laid out 2000*l.*, an enormous sum in those days, in the purchase of books, the construction of instruments, and the training up of young scholars to assist him in working out his calculations. Bacon then became a Franciscan. The order at first felt proud of possessing the greatest scholar in Christendom; but the monks soon grew jealous, and he was forbidden to teach, or even to study, until Clement IV. overruled the friars, and Bacon soon produced his *Opus Majus*, the first portion of a work to convey the totality of science. This was succeeded by two other treatises, the *Opus Minus* and the *Opus Tertium*. After Clement's death, Bacon's order again imprisoned him on account of "some suspected novelties;" he lived until 1292; but his enemies still feared him, and his manuscripts were locked up by the monks, and left to be eaten by insects!

Bacon was a great founder of physical science by his wise doubts and reverence for facts. He speaks of experimental philosophy as more perfect than all the natural sciences; "for it teaches us to test by trial the noble conclusions of all the sciences, which, in the others, are either proved by logical arguments or are examined on the imperfect evidence of nature; and this is its prerogative." As a workman in the laboratory, and with lenses, he himself discovers the history of explosive compounds, confirms the properties of burning-glasses, and the principle of the camera. His knowledge of medicine even extended to dietetics. In physical science he almost predicts the steam-boat and the railway-engine and the beam-bridge; Bacon believing that "engines of navigation may be made without seamen, so that the greatest river and sea ships, with only one man to steer them, may sail swifter than if they were fully manned. Moreover chariots," he thinks, "may be made so as to be moved with incalculable force without any beast drawing them." "And such things might be made to infinity, as, for instance, bridges to traverse rivers without pillars or any buttress." Although in these instances Bacon may have been rather a prophet than a teacher, he is admitted to have been by far the truest philosopher of the middle ages. One of the charges made against him was that of practising magic, which was then frequently brought against those who studied the sciences, and particularly chemistry. Yet in his tract *De Nullitate Magiæ* Bacon declares that experimental science enables us to investigate the practices of magic, not with the intent of confirming them, but that they may be avoided by the philosopher. Even his astrology and alchemy are, when considered by the side of a later age, irrational only because unproved; and neither impossible, nor unworthy of the investigation of a philosopher in the absence of preceding experiments.

ARNOLD DE VILLENEUVE.

Somewhat later than Lully lived Arnold de Villeneuve, born in 1240, and who was not only an alchemist, but an astrologer and magician, a physician, and well skilled in the sciences of his time. His *Rosarium* is a compendium of the alchemy of his day: the second part professes to treat of the making of the Philosopher's Stone, but is quite unintelligible. Like his predecessors, he considered mercury as a constituent of metals, and professed that he could increase the Philosopher's Stone at pleasure. He and Lully inspired men of all ranks with a taste for alchemy; among whom was Pope John XXII., who professed and described the art of transmuting metals, and boasted that he had made 200 ingots of gold, each weighing 100 pounds!

ALCHEMISTS OF THE 14TH AND 15TH CENTURIES.

The fourteenth century produced many alchemists; but the fifteenth century was still more productive in *adepts*—a term, by the way, which has passed from the technology of alchemy to that of chemistry, and thence into our language to denote persons completely skilled in the secrets of art. About 1408 flourished two kinsmen named Hollandus, who wrote several treatises on chemistry remarkable for clearness and precision; Boerhaave considered the kinsmen skilful chemists.

In England, a legislative blow was aimed at Alchemy in 1404, when an Act of Parliament was passed declaring the making of gold and silver to be felony. This shows the general belief in the art, since the law arose from the fear that some fortunate alchemist should succeed in his project, and thus bring ruin on the State. This alarm soon subsided; for in 1455 Henry VI., by advice of his council and parliament, granted patents and commissions to several knights, citizens of London, chemists, monks, mass-priests, and others, to find out the Philosopher's Stone and Elixir, "to the great benefit," said the patent, "of the realm, and the enabling of the king to pay all the debts of the Crown in real gold and silver." No gold, of course, was ever made. The king appointed a commission to inquire whether the transmutation of metals were practicable; but their report is not extant.

In this reign, at the east end of the road subsequently known as Pall Mall, stood a large low Gothic building, called the Rookery, belonging to the monks of Westminster. At the Reformation, when this building was demolished, there is a tradition that in a corner of an inner apartment the remains of a smithy were found, with a timber roof thickly incrusted with bituminous smoke. This smithy or forge was reputed to have been erected by order of Henry VI., that he might there attempt to replenish his empty coffers by alchemy: the record of this proposition contains solemn asseverations of the feasibility and virtue of the Philosopher's Stone; and the document is presumed to have been communicated by Selden to his friend Ben Jonson, when he was writing his comedy of the *Alchemist*, which, like *Albumazar* (in Dodsley's collection), satirises pretended adepts. Upon the site of the smithy in Pall Mall was built the first Carlton House.

GEORGE RIPLEY.

In the succeeding reign, George Ripley, the canon of Bridlington in Yorkshire, pretended to have discovered the secret. He wrote the *Medulla Alchymiæ;* and, in rugged rhyme, *The Compound of Alchemy; or, the Twelve Gates leading to the Discovery of the Philosopher's Stone*, which was dedicated to Edward IV. These gates Ripley described to be "calcination, solution, separation, conjunction, putrefaction, congelation, cibation, sublimation, fermentation, exaltation, multiplication, and projection." He left a few other compositions on Alchemy, which were printed by Ashmole. "They have no other merit (says Warton) than that of serving to develop the history of chemistry in England." Ripley is said to have been born at Boston, by others at Ripley in Yorkshire. His discovery of the Stone is dated 1470. Selden says: "Ripley, the alchemist, when he made gold in the Tower, the first time he found it, spoke these words, "*per medium eorum*, that is, *per medium ignis et sulphuris.*" He turned Carmelite at St. Botolph's in Lincolnshire, and died an anchorite in that fraternity, in 1490. (Thompson's *History and Antiquities of Boston*, 1856.) Ripley appears to have repented of his wasted life, to have acknowledged that his studies were nothing worth, and requested that all men, when they met with any of his books, would *burn them*, or afford them no credit, as they were "false and vain." Such is the statement of Fuller, in his *Worthies of England.*

BASIL VALENTINE.

Basil Valentine, a Benedictine monk of Erfurt in Germany, born about the end of the 14th century, was the next famous professor of the hermetic philosophy, and was likewise a skilful experimentalist in chemistry. He was of opinion that the metals were compounds of salt, sulphur, and mercury; and that the Philosopher's Stone was composed of the same ingredients. He was acquainted with many of the properties of several metals, and with the effects of their chemical agency. He first introduced antimony into medicine, and knew most of the preparations of it which at present exist in the pharmacopœias of Europe. In his famous *Currus Triumphalis Antimonii*, he says: "Antimony, like unto mercury, may fitly be compared to a round circle, of which there is no end; in which the more diligently any man seeks, the more he finds, if process be made by him in a right and due order. *Yet the life of no one man is sufficient for him to learn all the mysteries thereof.*" With what astonishment would Basil, if he could revisit the earth for half an hour, hear of antimonious, antimonic, and metantimonic acids; of antimoniuretted hydrogen, penta-sulphide of antimony, stibio-methyle, stibio-ethyle, and the like. The coaches of his day did not differ more from the railway-carriages of ours than his "Currus Triumphalis" does from such a Triumphal Chariot of Antimony as Hofmann, if he chose, could mount upon literary wheels at the present day. Yet Hofmann could find no better motto to put upon the panel of his chariot than Basil's words, "No one knows all the virtues of Antimony;" and I may add (says Dr. Wilson), no man ever will; nor is the chemist better off in respect to other things than he is in respect to Valentine's favourite metal.* His works contain the first accurate mention of the nitric, muriatic, and sulphuric acids, with intelligible directions for preparing them; and he was acquainted with a very considerable number of metallic salts and compounds.

AGRIPPA.

Cornelius Agrippa, born in Cologne in 1486, began in his youth the study of chemistry and philosophy; and at the early age of twenty was so famous an alchemist that the principal adepts of Paris invited him to settle in France, and aid them with his experience in discovering the Philosopher's Stone. He was professedly a physician; but allowed himself to be regarded as an alchemist, an astrologer, and even as a practitioner of magical arts. He died in poverty in 1535.

PARACELSUS.

Paracelsus, "the zenith and rising sun of all the alchemists," was born near Zurich at the close of the fifteenth century. He was early initiated into the secrets of astrology and alchemy by his father, who was a physician, and by the Abbé Trithreim. He passed his youth in visiting mines, curing diseases, foretelling the future, and seeking the Philosopher's Stone. He is said to have learned a few secrets of alchemy from some Tartars, by whom he was made prisoner in Poland; and he obtained some further mysteries in a journey to Egypt.

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* From Dr. George Wilson's admirable Essay on Chemical Final Causes (*Edinburgh Essays*, 1856).

He read little, but talked and listened to all classes. Alchemy was at this time falling into discredit, when Paracelsus undertook to revive and rehabilitate the study. In 1526 he returned to Switzerland, where a lucky and striking cure led to his being appointed Professor of Physic and Surgery at Basle. He there set himself in opposition to all doctors, past and present, when the students joined him in his attack upon the Schools, and burned the writings of Hippocrates, Galen, and Avicenna in the very court of the University. Some lucky cures confirmed his reputation, but it lasted only a short time. He flew to dissipation, became a wandering quack, and died in his forty-eighth year. As a medical reformer, he propounded a novel and striking Physiology. Nevertheless he broke down in his two great pretensions; for this boasted possessor of the Philosopher's Stone and the Elixir of Life died in poverty at an early age. His discoveries were, however, important. To him we owe the idea of employing poisons as medicines; he made known to Europe various preparations of antimony, mercury, iron, &c.; he employed preparations of lead for diseases of the skin, and first used copper, arsenic, and sulphuric acid as medicaments. "The vaunts of Paracelsus of the power of his chemical remedies and elixirs, and his open condemnation of the ancient pharmacy, backed as they were by many surprising cures, convinced all rational physicians that chemistry could furnish many excellent remedies unknown till that time. A number of valuable experiments began to be made by physicians and chemists; and the chemical and metallurgic arts, exercised by persons empirically acquainted with the secrets, began to be seriously studied, with a view to the acquisition of rational and useful knowledge."

Paracelsus therefore gave a most important turn to pharmaceutical chemistry; and calomel, with a variety of mercurial and antimonial preparations, as likewise opium, thenceforth came into general use. He had learned the properties of opium from Turkey; the physicians of his time being afraid of this drug as "cold in the fourth degree." Tartar was likewise a great favourite of Paracelsus, who gave it that name, "because it contains the water, the salt, the oil, and the acid which burn the patient as hell (Tartarus) does." Such was the influence of Paracelsus, that a sect of Paracelsists sprang up in France and Germany to perpetuate his extravagant doctrines, and the term Paracelsic was afterwards applied to the vocabulary of alchemists. His magical doctrine appears to have been founded upon the supposed existence of the Philosopher's Stone. He maintained that the Bible was the key to the theory of all diseases, and that the Apocalypse shows the signification of modern medicine. The man who could identify himself with the celestial intelligences possessed the Philosopher's Stone, he could cure all diseases, and prolong life as many centuries as he pleased ; it being by the very same means that Adam and the antediluvian patriarchs prolonged theirs. In the stomach of every man there dwelt a demon, or intelligence, that was a sort of alchemist, and mixed in their due proportions, in his crucible, the various aliments that were sent into that grand laboratory the belly. Paracelsus was proud of the title of magician, and advocated potable gold and the Elixir of Life. He imagined that gold could cure the ossification of the heart, and, in fact, all diseases, if it were gold which had been transmuted from an inferior metal by means of the Philosopher's Stone, and if it were applied under certain conjunctions of the planets. Thus we see that his application of the Stone was to the curing of diseases.

BAPTISTA PORTA.

Porta, in the book of his *Natural Magic* which he devotes to "Alchemy," is strangely inconsistent. He acknowledges that he neither promised the Stone nor the Elixir, which are mere dreams. He commends Dioclesian for having destroyed the treatises on Alchemy ; and agrees with Demetrius Phalereus, "that what the alchemists should have gotten, they got not ; that what they had, they lost ; and the transmutation which they sought took place, not in the metal in their furnaces from lead to gold, but in their own circumstances from good to bad." Yet, in the very next chapter, Porta treats "of tin, and how it may be converted into a worthier metal ;" and he even tells us how to change silver into gold, though sometimes he seems to consider his recipes as genuine, and at other times as clever impositions. He next treats of counterfeiting precious stones, not by solution and recrystallisation, but by colouring glass, and putting coloured foil under the setting.

ALCHEMISTS AND COINERS.

In the reign of Elizabeth, certain persons who, by the practice of Alchemy, proposed to add to or imitate the Queen's coin, were committed prisoners to the Tower of London.

"The chief of these was Cornelius de Launoy, an alchemist, who gravely proposed to the Queen to put in operation the Wonderful Elixir, and to make any metal into gold and gems. He so far succeeded with her as to be allowed to carry on his works at Somerset House. Of course he failed : on being reported to have greatly abused the Queen's confidence, he was committed to the Tower in 1566, where he still professed to be able to perfect his experiments, had it not been for the obstacles thrown in his way.

"In July 1570, two other alchemists, who had been inclined to practise on their own account, were also favoured with an asylum here: they were John Bulkeley, a student at Oxford, and William Bedo, a stationer, who proposed to cast a figure for the recovery of lost money, and professed to have many alchemical secrets for diminishing and lessening the coin of the realm by sweating, &c."—*M. W. Durrant Cooper, Archæologia*, vol. xxxvii.

DEE AND KELLY.

Dr. Dee, and his assistant Edward Kelly, were more notorious as practitioners of magic than of alchemy. Dee, when at Cambridge, quitted the mathematics and the pursuits of true philosophy for alchemy, astrology, and magic, and thereby rendered himself obnoxious to the authorities of the University. He was suspected of sorcery; and to avoid persecution, he fled to Louvain, where many followers of Cornelius Agrippa encouraged him to give himself up to the search for the Philosopher's Stone. Upon his return to England, he settled in London as an astrologer, casting nativities, telling fortunes, and pointing out lucky and unlucky days. He was charged with attempting Queen Mary's life by means of enchantment, and narrowly escaped burning in Smithfield. Though Dee lived by astrology, his heart was in alchemy. He deeply studied the Talmudic mysteries, and believed that he might hold converse with spirits and angels, and learn from them all the mysteries of the universe. He persuaded himself that an angel appeared to him, and gave him a crystal, in which spirits would appear to him; and he similarly employed a "show-stone," a piece of polished cannel-coal. He then employed Kelly to take down in writing the revelations he received from the spirits; but the man was much more of an impostor than his master. Meanwhile Dee, who had enjoyed the favour of the Princess Elizabeth, was counselled by him as to her coronation-day, and Elizabeth supported him when queen: she consulted him at his house at Mortlake upon state matters, and thither crowds flocked to have their nativities cast. He pretended to have found a vial of *Elixir Vitæ* among the ruins of Glastonbury Abbey; but he is stated to have spent so much in drugs and metals to work out his transmutations that he never became rich. He made a long tour on the Continent, and gained dupes even among crowned heads: while there, he sent to Queen Elizabeth a round piece of silver, which he pretended he had made of a portion of brass cut out of a warming-pan. At length he parted with Kelly; and thrown upon his own resources, began in earnest to search for the Philosopher's Stone: he worked incessantly among his furnaces, retorts, and crucibles ; he consulted his crystal.* But having parted with Kelly, who had been the main-spring of the imposition, the spirits would not appear ; he tried other helpmates, but without success; he could get no information on the Stone or Elixir, and so fell into want. During his absence from England, a mob had pillaged his house at Mortlake, and had burnt his books, and destroyed his instruments and curiosities in his museum, accusing him of being a necromancer and wizard. For this damage he claimed compensation, but received only small sums from the Queen. He, however, was subsequently appointed Warden of the College at Manchester, which post he resigned in seven years, and then returned to Mortlake, where he died in poverty in 1608, and was buried in Mortlake church. Dee had a son, Arthur, whom he employed as a *skryer*, or inspector of his magical glass, when he was a boy. He wrote a tract on Alchemy, or the Hermetic Science, published in 1631.

SIR THOMAS BROWNE AND THE ALCHEMISTS.

Sir Thomas Browne, in letters to Lilly and Ashmole, bears testimony most unequivocally to the sincerity of Dr. Arthur Dee's belief in the power of alchemy to transmute the baser metals into gold and silver, which he assured Sir Thomas he had "ocularly, undeceivably, and frequently" beheld. He was even on the point of going to the Continent in pursuit of such riches, had not the death of the artist, with whom he was about to hazard his property, most opportunely prevented him. Sir Thomas had also another zealous alchemist among his correspondents, in the person of Sir Robert Paston, with whom he communicated from 1663 to 1672, principally on experiments which Sir Robert was making in alchemy. But Browne himself did not place any reliance upon alchemical studies, which, however, he regarded as the cradle of chemistry.

SERVICES OF ALCHEMY TO MEDICINE.

The Pharmacopœia of the Galenical school contained no chemical preparations, and consisted exclusively of organic substances : musk, rhubarb, castoreum, camphor, tamarinds, ginger, zedoary root, and the like, were the chief remedies. Pharmacy then consisted in the art of bringing these matters into the form of syrups and electuaries ; herbs, barks, and roots were administered in the form of decoctions or of powders. On the authority of Galen, all metallic preparations were up to that time banished from the Pharmacopœia. He regarded mercurial preparations simply as poisons. Avicenna, it is true, had ascribed to gold and silver powers of purifying the blood; but these metals, as a general rule, were used only in the form of leaf to cover pills;* and so late as the end of the fifteenth century, the external use of mercurial ointments, prepared with fat, encountered the fiercest opposition.

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* See the account of Dee's Crystal in *Popular Errors Explained*, p. 143.

The views of Galen as to the cause of disease and the action of remedies, after having been for thirteen centuries regarded as impregnable truths, in the sixteenth century yielded to the discovery of the truly wonderful effects of the preparations of mercury, antimony, and other metals, when a whole region of new discoveries seemed to be opened up by the ideas of the alchemists, and by the use of chemical preparations in medicine.

THE TWO NAPIERS, ALCHEMISTS.

Some original documents among the family archives of Napier of Merchiston, the inventor of *Logarithms*, prove this great philosopher was a believer in the doctrines of Hermes. One of these documents records, on Nov. 7, 1607, Napier's conference with Mr. Daniel Muller, Doctor of Medicine and Student in Alchemy, at whose bedside Napier declares himself to have been many years a very earnest student in alchemy; and to have received from a credible friend, whom he sent to the mines of Histria, a Venetian province at the top of the Adriatic, "a little piece of the earth of those mines, about the quantity of a hazel-nut, which, as he brake, there appeared scales of quicksilver within the same, and the crude mercury flowed forth without the fire. With this (says Napier) I perfected the philosophical work, as you may do with the like; for this mercury, being taken with fine silver which never did find fire, and enclosed in a matrix, will become black within the space of forty days, and thereafter will become white: and then is the point and term to loose it, if you do not join it with fine gold that never did find the fire, when instantly that which was taken of mercury and *luna* (or silver) will devour up the gold; and at this conjunction or fermentation endeth the first work, called *opus lunæ* (the silver operation), and beginneth immediately the second, called *opus solis* (the golden operation).

In this *opere solis* your work becomes blacker than in *opere lunæ*, and then white, and at last red.

Both these works are performed in a year, to wit, two months and a half in *opere lunæ*, and nine months and a half in *opere solis*.

And for *pondera* I take nine of crude mercury for one of crude *luna* (or silver), and this I conjoin with one of *sol* (or gold) in *secundo opere*.

So *luna* is the *medium conjungendi;* and hereof cometh three mercurios, to wit, the first, which is *mercurius crudus,* and is called *mercurius frigidus, acetum, mercurius mineralis;* the second, which is *luna* dissolved in crude mercury to the point of whiteness, is called *mercurius tepidus, acetum, acerrimum, mercurius vegetabilis, quia luna est planta* (because silver is the root); the third, which is *sol* dissolved by the second, is called *mercurius calidus, mercurius animalis.*

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* The arms of the Medici of Florence were three gilded pills, in allusion to the professional origin of their name. Indeed, medical signs were generally gilded; as the *Golden Key*, Galen's Heads, and the *Golden Pestle and Mortar*. We remember the latter sign in Pall Mall, at the house next to which lived Dr. Sydenham. The *Golden Phœnix* is directly of hermetic origin.

'Further,' said he (Dr. Muller), 'the little cipher-table entitled "Medulla Philosophiæ Hermeticæ," it is mine, for I made it.'

Also he added many discourses, citing texts out of Clangor Buecinæ, Marsilius, Ripleus, and Arnoldus, to prove the premises, and especially 'De Terra Nigra Occulosa, Terra Hispanica,' &c.

Further, he said that the various-hued glass which I did see was in that manner, throughout all its texture, coloured with the stuff which he made in that same glass.

Further, he spake to the *triplici usu lapidis,* after Paracelsus: first, in transmutations of metals; secondly, in curing diseases; and thirdly, it is *lapis divinus,* for magical uses.

Now when I heard these things, and had said unto him, 'My lord, that matter is marvellous, if you be sure of the truth thereof by practice,' he answered, with earnestness, 'In truth I have practised it to the end, and made projection, and found it true.'

Again, when I demanded of him how it fortuned that he did not multiply his stuff, and keep the same, he answered, 'I lacked crude mercury, without which it cannot be multiplied again.'

Upon the 9th of November, I conferred with him again anent some doubts, *quod fons trahit regem, et non rex fontem,* and so doth *aqua regis;* but vulgar mercury, on the contrary, *non trahit solem, sed sol eum!* He answered, that whatever vulgar mercury or crude mercury do, yet this mercury philosophical, of crude mercury and silver, will instantly drink up gold, and draw it in, *initio secundi operis.* Then I demanded when should the second work begin, and what was the sign before the point of danger to the work. He answered, that after perfect whiteness *in opere primo,* there would appear, in an instant, a small hair-like circle surrounding the matter, and attached to the sides of the vessel; then instantly ferment with gold, and it will presently eat up all the gold, and that circle will vanish; but if you stay longer in fermenting, the work will become all *citrine,* and more dry than it can dissolve the gold; for the gold must be sown *in terram albam foliatam.*

Then I demanded what *terra alba foliata* was. He answered, that at the point of whiteness, in the first operation, the matter of mercury and *luna* became like the small scales of a fish. Then I remembered that my father showed me that he made a work which became *terra alba foliata,* most like the leaves of a book set on edge, of *sol, luna, aqua regis,* and *aqua fortis.*

Thereafter, about the 15th day of March 1608, the doctor showed me that he had received glad tidings of the safe return of Lionel Struthers, his said friend, from Histria, to England; and he showed me a certain antique figure, with certain verses of congratulation which he had made, and was sending to him in joy of his safe return.

So, within ten days, he came to Edinburgh to the Doctor, and brought with him great store of mineral mercury, which never had felt fire, and some unfined, easy to be wrung out from his ore. The Doctor gave me secretly a small portion both of the one and of the other; as also a very small part of *luna* mineral unfined; but I purchased more, both of Scotch and German *luna.* As for *sol* (gold) mineral, we have enough in Scotland, rests time and opportunity to enterprise the work, with the blessing of God to perform the same, to his glory and comfort of his servants, which the Almighty grant to us, whose holy name be praised and magnified for ever and ever. Amen."

From another Ms. preserved in the Napier charter-chest, written subsequently to the death of the inventor of logarithms by his younger son, Robert Napier, faith in alchemy would appear to have been on the increase. The son had toiled far more devotedly than his somewhat sceptical father. Robert, by extracting the marrow of all the hermetic philosophers and authors who preceded him, professed to bequeath to his son the grand secret itself! It is written throughout in Latin. In the preface he states:

> It has been ordained by Divine Providence that this science should be transmitted to us from Hermes, its first inventor, down even to these times, a period of nearly four thousand years, through the hands of the learned—the majesty of the great mystery being protected in a cabalistic form. That such a science exists has also been made known to us through books; but these, for the most part, are so full of enigmas, allegories, and figures of speech, nay of falsities, mystifications, and contradictions, that they seem rather to have been written for misleading than for instructing. Long would be the time, and weary the wandering in error, ere this divine art could be acquired by any one from the books of the philosophers, without a faithful guide.

SIR ISAAC NEWTON'S BELIEF IN ALCHEMY.

We gather from a chapter in Sir David Brewster's *Life of Sir Isaac Newton* some testimony to Sir Isaac's belief in Alchemy, and his early taste for practical chemistry, which he doubtless first acquired during his residence with Mr. Clark the apothecary at Grantham. In April 1669, he records the purchase in London of "aqua fortis, sublimate, oyle pink, fine silver, antimony, vinegar, spirit of wine, white lead, salt of tartar, ☿, together with a furnace and an air-furnace."

Sir David says, "in Newton's chemical studies his mind was impressed with some belief in the doctrines of Alchemy, and he certainly pursued his experiments to a late period of his life, with the hope of effecting some valuable transmutations." Among the subjects which he requests his young friend Mr. Aston, about to make a tour on the Continent, to pay attention to, there are several which indicate this tendency of Newton's mind. "He desires him to observe the products of nature, especially in mines, with the circumstances of mixing and of extracting metals or minerals out of their ores, and refining them; and, what he considered of far more importance than this, he wishes him to observe if there were any transmutations out of one species into another; as, for example, out of iron into copper, out of one salt into another, or into an insipid body, &c. Such transmutations," he adds, "are above all others worth his noting, being *the most luciferous, and many* *times luciferous experiments too, in philosophy!*" He also names "a certain vitriol which changes iron into copper," and which is said to be kept a secret for the lucrative purposes of effecting that transmutation. He is to inquire also whether in Hungary, or in the mountains of Bohemia, there are rivers whose waters are impregnated with gold, dissolved by some corrosive fluid like aqua regis; and whether the practice of laying mercury in the rivers till it be tinged with gold, and then separating the gold by straining the mercury through leather, be still a secret or openly practised. There was at this time in Holland a notorious alchemist of the name of Bory, who, as Sir Isaac says, was some years since imprisoned by the Pope, in order to extort from him secrets of great worth both as to medicine and profit, and who made his escape into Holland, where they granted him a guard. "I think," adds Sir Isaac, "he usually goes clothed in green. Pray inquire what you can of him, and whether his ingenuity be any profit to the Dutch!" Whatever were the results of Mr. Aston's inquiries, they did not damp the ardour of Newton in his chemical researches, nor extinguish the hope which he seems to have cherished of making "philosophy luciferous by transmuting the baser metals into gold."

The Rev. Mr. Law has stated that there were found among Sir Isaac's papers large extracts out of Jacob Behmen's works, written with his own hand; and that he had learned from undoubted authority that in a former part of his life he was led into a search of the Philosopher's Tincture from the same author. He afterwards stated in a private letter that his vouchers are names well known, and that they have assured him that "Sir Isaac was formerly so deep in Jacob Behmen, that he, together with Dr. Newton, his relative, set up furnaces, and were for several months at work in quest of the Tincture. That this statement is substantially true is proved by Dr. Newton's own letter, in which he says: 'About six weeks at spring, and at y^e^ fall, y^e^ fire in the elaboratory scarcely went out, which was well furnished with chymical materials, as bodyes, receivers, heads, crucibles, &c., which was made very little use of, y^e^ crucibles excepted, in which he fused his metals. He would sometimes, tho' very seldom, look into an old mouldy book which lay in his elaboratory. I think it was titled *Agricola de Metallis;* the transmuting of metals being his chief design, for which purpose antimony was a great ingredient. Near his elaboratory was his garden. . . . His brick furnaces, *pro re nata,* he made and altered himself, without troubling a bricklayer.'"

Sir David Brewster has seen, in Newton's handwriting, *The Metamorphoses of the Planets,* by John de Monte Snyders, in sixty-two pages quarto; also, a Key to the same work, and numerous pages of alchemist poetry from Norton's *Ordinal* and Basil Valentine's *Mystery of the Microcosm*. There is also a copy of *Secrets Revealed; or, an open entrance to the Shut Palace of the King*,* which is covered with notes in Sir Isaac's hand, in which great changes are made upon the language and meaning of the thirty-five chapters of which it consists. Sir David has likewise found amongst Sir Isaac's papers a beautifully written but incomplete copy of William Yworth's *Processus Mysterii magni Philosophicus*, and also a small manuscript in his handwriting entitled *Thesaurus Thesaurorum sive Medicina Aurea.*

Newton too left behind him, in his note-books and separate Mss., copious extracts from the writings of the alchemists of all ages, and a very large *Index Chemicus* and *Supplementum Indicis Chemici*, with minute references to the different subjects to which they relate.

BOYLE'S PROCESS FOR "MULTIPLYING GOLD."

In 1692, while Newton was in correspondence with Locke, the process of the Hon. Robert Boyle for "multiplying gold," by combining a certain red earth with mercury, became the subject of discussion. Boyle had, before his death, communicated this process both to Newton and Locke, and procured for them some of the red earth. It is obvious from letters extant that both the philosophers were desirous of "multiplying gold." Newton says that several chemists were engaged in trying the process, adding that Mr. Boyle, in communicating it to himself, "had reserved a part of it from my knowledge, though I knew more of it than he has told me."

This mystery on the part of Boyle (says Brewster) is very remarkable. In "offering his secret to Newton and Locke, he imposed conditions upon them, while, in the case of Newton at least, he did not perform his own part in the arrangement." On another occasion, when he communicated two experiments in return for one, "he cumbered them," says Newton, "with such circumstances as startled me, and made me afraid of any more."

It is a curious fact, as appears from this letter, that there was then a company established in London to multiply gold by this recipe, which Newton "takes to be the thing for which Mr. Boyle procured the repeal of the Act of Parliament against multipliers." The pretended truths in alchemy were received by men like Boyle on the same kind of evidence as that by which the phrenology and clairvoyance of modern times have been supported. Although Boyle possessed the golden recipe for twenty years, yet Newton could not find that he had "either tried it himself, or got it tried successfully by any body else; for," he says, "when I spoke doubtingly about it, he confessed that he had not seen it tried, but added, that *a certain gentleman was now about it, and it succeeded very well, so far as he had gone, and that all the signs appeared so well that I need not doubt of it.*"

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* By W. C., Lond., 1699, 8vo. "Composed by a most famous Englishman, styling himself *Anonymus*, or *Eurœneus Philaletha*, who, by inspiration and reading, attained to the Philosopher's Stone at the age of twenty-three years. Anno Domini, 1645."

Boyle, in his physical inquiries, insisted upon the importance of individual experiments, and the comparative unimportance of the facts which on certain subjects antiquity has handed down. Humboldt well calls him "the cautious and doubting Robert Boyle." He even gave to his most popular work the title of *The Sceptical Chemist,* implying how sceptical he was of the science of his own time; and he often avows his doubt and diffidence of the opinions he inclines to. Yet amidst this legion of difficulties of belief, Boyle believed in the efficacy of Valentine Greatrakes's cure of the Evil, and even contributed to the *Philosophical Transactions,* No. 256, an account of Greatrakes, founded upon his own letter addressed to Boyle. A century and a half since, Boyle's *Works,* from their popularity, were becoming scarce; and Dr. Johnson, in the last century, considering how much of our philosophy is derived from Boyle's discoveries, held his writings to be neglected, though his name was reverenced. A reaction in the demand for his *Works* has sprung up; and at the time we write (1860), in accordance with the inquiring, not to say sceptical, spirit of the times, Boyle is again in great request. A handsome edition of his *Occasional Reflections* was reprinted at Littlemore, and published at Oxford in 1848, and is already scarce. It is a delightful "occasional" book; worth a cartload of light literature.

BELIEF OF GREAT MEN IN ALCHEMY.

There is no problem (says Sir David Brewster) of more difficult solution than that which relates to the belief in Alchemy, and to the practice of its arts, by men of high character and lofty attainments.

When we consider that a gas, a fluid, and a solid may consist of the very same ingredients in different proportions; that the same elements, with one or more atoms of water form different substances; that a virulent poison may differ from the most wholesome food only in the difference of quantity of the very same ingredients; that gold and silver, and, indeed, all the metals, may be extracted from transparent crystals, which scarcely differ in their appearance from a piece of common salt or a bit of sugar-candy; that *Aluminium,* a metal with almost all the valuable properties of gold and platinum, can be extracted from clay; that light of the most dazzling colours can be obtained from the combustion of colourless salts; that gas giving the most brilliant light resides in a lump of coal or a block of wood; that several of the gems can be crystallised from their elements; and that diamond is nothing more than charcoal,—we need not wonder that the most extravagant expectations were entertained of procuring from the basest materials the precious metals and the noblest gems. In the daily experiments of the alchemist, his aspirations after great discoveries must often have been encouraged by the singular phenomena which he encountered, and the startling results at which he arrived. The most ignorant compounder of simples could hardly fail to witness the almost magical transformations of chemical bodies; and every new product which he obtained must have added to the probability that the tempting doublet of gold and silver would be thrown from the dice-box with which he gambled. When any of the precious metals were actually obtained from the ores of lead and other minerals, it was not unreasonable to suppose that they had been formed during the process; and men not disposed to speculate might have thus embarked in new adventures to procure a more copious supply, without any insult being offered to sober reason, or any injury inflicted on sound morality.—*Life of Sir Isaac Newton*, vol. ii. pp. 372-3.

Sir David Brewster maintains that the Alchemy of Boyle, Newton, and Locke must not be considered to have been prompted either by the ambition of wealth or of praise, but a love of truth alone, a desire to make new discoveries in chemistry, and a wish to test the extraordinary pretensions of their predecessors and their contemporaries. In so far as Newton's inquiries were limited to the transmutation and multiplication of metals, and even to the discovery of the Universal Tincture, we may find some apology for his researches; but we cannot understand how a mind of such power, and so nobly occupied with the abstractions of geometry and the study of the material world, could stoop to be even the copyist of the most contemptible alchemical poetry, and the annotator of a work the obvious production of a fool and a knave.

Leibnitz, Newton's great rival, was also an alchemist; he joined a society of Rosicrucians at Nuremberg, in the pursuit of the Philosopher's Stone. Leibnitz, however, soon renounced his faith in the mystic art; and there is reason to believe, from one of Newton's letters to Locke, that he had also learned to have but little confidence even in the humbler department of the multiplication of metals.*

VAN HELMONT.

Van Helmont worked most ingeniously in the illustration of Alchemy. When Thales had asserted that water was the first of the elements, and that all the visible creation deduced therefrom its origin, it was said in subsequent ages that the planets, according to their own power and their position in fiery, airy, earthy, and watery signs, so acted upon the fluid mass as to produce that quaternion of elements alone, for a long time, admitted by the philosophers:

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* When Locke, as one of the executors of Boyle, was about to publish some of his works, Newton wished him to insert the second and third part of one of Boyle's recipes (the first part of which was to obtain "a mercury that would grow hot with gold"), and which Boyle had communicated to him on condition that they should be published after his death. In making this request, Newton "desired that it might not be known that it came through his bands." And he adds: "One of them seems to be a considerable experiment, and may prove of good use in medicine in analysing bodies. The other is only a knack. In dissuading you from too hasty a trial of this recipe, I have forborne to say any thing against multiplication in general, because you seem persuaded of it, though there is one argument against it which I could never find an answer to, and which, if you will let me have your opinion about it, I will send you in my next." (Letter to Locke, Aug. 2, 1692: Lord King's *Life of Locke*, vol. i.)

Air, and ye elements, the oldest birth
Of Nature's womb, that in quaternion run,
Perpetual circle, multiform, and mix
And nourish all things. *Milton.*

Van Helmont took up this doctrine of Thales, and attempted to prove its correctness by the following experiment: He took a vessel of earth, carefully levigated, and which weighed exactly two hundred pounds. In this he planted a willow, which weighed five pounds. After the lapse of five years, he took the willow from the earth, and weighed it: it had increased to 164 pounds. He also weighed the earth, which had not increased or decreased in weight. From this he argued, that, as he had carefully prevented any thing from being put to the earth but water, and as the earth in the vessel had lost nothing of its quantity,—the wood, the sap, and all the materials of which the tree might be found by analysis to consist, were all composed of water alone. "Hence," said he, "we need nothing but water to form gold; since, by means of this element, we make a tree, a plant, an animal, even an entire world." The reasoning used by Van Helmont must have been unanswerable in his day, for the solution of the phenomenon required a far more advanced state of chemical science than at that time existed. Van Helmont pretended to have once performed with success the process of transmuting quicksilver, and was, in consequence, invited by Rudolph II. to fix his residence at the Court of Vienna.

With a much greater show of reason he noticed some of the properties of, what he calls, gas sylvestre, or carbonic-acid gas: he observes that it is invisible, but that it was fixed in bodies; and he attributes the phenomena of the Grotto del Cane to its presence.

GLAUBER AND BRANDT.

Glauber, the laborious German chemist, who died in 1688, although an alchemist and believer in the Universal Medicine, greatly improved many chemical processes. He discovered the salt which yet bears his name; he greatly improved the manufacture of nitric and muriatic acids; and in his work is a rude representation of the implement now known as Woulfe's Apparatus. To Glauber we also owe the first production of pyroligneous acid; the distillation of ammonia from bones, and its conversion into sal ammoniac by the addition of muriatic acid; the preparation of sulphate of ammonia, and its conversion into muriate by the agency of common salt; and the production of sulphate of copper by acting upon green rust of copper with sulphuric acid.

To Brandt, the alchemist, of Hamburg, we owe the discovery, in 1669, of the elementary non-metallic body phosphorus, which he procured from urine, while searching for some substance capable of transmuting silver into gold. He kept the mode of preparation for a long time secret; but as he could not conceal the fact of its being obtained from urine, Kunckel, another alchemical adept, tried to obtain it from the same source, and succeeded. Kunckel also left a valuable treatise on Glass-making.

GEOFFROI AND HOMBERG.

In the eighteenth century some operations were made which for a while revived the hopes of hermetic students, and led them to consider "the great secret as almost within their grasp;" and these bright hopes were encouraged by Geoffroi and Homberg, the latter a seeker, and, as he himself once thought, no unsuccessful one, of the Philosopher's Stone. About the year 1735, there was established at Paris a manufactory with the object of changing iron into copper; and, as it was indubitable that a quantity of copper was actually sent out of this manufactory, and it was equally certain that nothing but iron and a certain vitriolic solution was used, this was believed to be but the first step of a series of transmutations; since he who began by transmuting iron into copper would doubtless soon transmute that copper into silver, and the silver into gold. Much capital was invested in the Paris scheme; but the manager of the works soon disappeared, leaving behind him only a small quantity of iron, and some blue vitriol, or sulphate of copper. The mystery was now cleared up; the copper contained in the vitriol had been precipitated upon the iron, which had been dissolved in turn, and thus the appearance of transformation had been effected. A short time before this, M. Geoffroi had declared that by a certain union of clay and linseed-oil iron had been formed. The Alchemists of course rejoiced: if it were possible, even without a metal, to make iron, easier was it to make gold by means of an inferior metal. But M. Geoffroi had overlooked the fact that iron already existed in the clay as a colouring oxide, and he candidly acknowledged his error. Five years previously, M. Homberg had declared that he had not transmuted lead or any inferior substance into gold, but the change of gold itself into glass. Still, no other person was able to produce the same results. Among those who attempted was the Landgrave of Hesse Cassel, who had apparatus made for the purpose; but neither he nor any one who tried succeeded, save Homberg himself.

BERGMANN AND THE ALCHEMISTS.

Bergmann, the distinguished chemist, born in West Gothland in 1735, in his *History of Chemistry during the Middle*

Ages, gives a number of cases in which gold has been supposed to be formed by the use of the Philosopher's Stone. They were unquestionably the result of fraud, by secretly introducing into the crucible gold, which they pretended to have obtained by transmutation. But Bergmann observes respecting the probability and possibility of transmutation, that although most of the narratives are deceptive, and many uncertain, some bear such character and testimony, that, unless we reject all historical evidence, we must allow them entitled to confidence. "For, doubtless," he adds, "if a person who has no faith in the changes of alchemistry should obtain by chance a small piece of the Philosopher's Stone, and, on making the experiment alone in his closet, procure a quantity of gold heavier than the Stone, will it not be difficult to explain in what manner he was deceived ?" Before the difficulty is required to be explained, it must, however, be placed on incontestable evidence.

DR. PRICE THE ALCHEMIST.

Towards the close of the last century, Dr. James Price, a medical practitioner in the neighbourhood of Guildford, Surrey, acquired some notoriety by an alleged discovery of methods of transmuting mercury into gold or silver. He had been a student of Oriel College, Oxford, where he obtained the degree of Bachelor of Physic. In 1782 he published an account of his Experiments on Mercury, Silver, and Gold, performed at Guildford, in that year, before Lord King and others, to whom he appealed as eye-witnesses of his wonder-working power. It seems that mercury being put into a crucible, and heated in the fire with other ingredients (which had been shown to contain no gold), he added a red powder; the crucible was again heated, and being suffered to cool, amongst its contents, on examination, was found a globule of pure gold. By a similar process, with a white powder, he produced a globule of silver. The character of the witnesses of these manifestations gave credit and celebrity for a time to Price, who was honoured by the University with the degree of Doctor of Physic; and he was also elected a Fellow of the Royal Society. Dr. Price had now placed himself in a perilous position; for persons acquainted with the history of alchemy must have conjectured how the gold and silver in his experiments might have been procured without any transmutation of mercury or any other substance. The Royal Society authoritatively required that the pretensions of the new associate should be properly sifted, and his claim as a discoverer be clearly established, or his character as an impostor exposed. A repetition of the Doctor's experiments before a committee of the Royal Society was commanded on pain of expulsion; when the unfortunate man, rather than submit to the ordeal, took a draught of laurel-water,* and died on July 31, 1783, in his twenty-fifth year.

NINETEENTH CENTURY.

At the beginning of the present century, some persons of eminence in science thought favourably of Alchemy. Professor Robison, writing to James Watt, Feb. 11, 1800, says: "The analysis of alkalies and alkaline earths will presently lead, I think, to the doctrine of *a reciprocal convertibility of all things into all; . . . and I expect to see alchemy revive*, and be as universally studied as ever."*

Sir Walter Scott, in his excellent paper on Astrology and Alchemy in the *Quarterly Review*, 1821, relates that about 1801 an adept lived, or rather starved, in the metropolis, in the person of an editor of an evening journal, who expected to compound the alkahest if he could only keep his materials digested in his lamp-furnace for the space of seven years. The lamp burnt brightly during six years, eleven months, and some odd days besides, and then unluckily it went out. Why it went out the adept never could guess; but he was certain that if the flame could only have burnt to the end of the septenary cycle, his experiment must have succeeded.

PETER WOULFE.

The last true believer in alchemy, according to Mr. Brande, was Peter Woulfe, the eminent chemist, associated with Woulfe's Apparatus, for condensing gaseous products in water, and a Fellow of the Royal Society. Among his contributions to the *Philosophical Transactions* are "Experiments to show the nature of Aurum Mosaicum."

Woulfe was a tall, thin man; he died in Barnard's Inn, Holborn, in 1805, and his last moments were remarkable. By his desire, his laundress shut up his chambers, and left him, but returned at midnight, when Woulfe was still alive: next morning, however, she found him dead; his countenance was calm and serene, and, apparently, he had not moved from the position in which she had last seen him.—*Curiosities of London.*

Little is known of Woulfe's life. Sir Humphry Davy states that he used to affix written prayers and inscriptions of recommendations of his processes to Providence. His chambers were so filled with furnaces and apparatus that it was difficult to reach his fireside. Dr. Babington told Mr. Brande that he once put down his hat, and never could find it again, such was the confusion of boxes, packages, and parcels that lay about the room. His breakfast-hour was four in the morning; a few of his select friends were occasionally invited, and gained entrance by a secret signal, knocking a certain number of times at the inner door of the chambers. He had long vainly searched for the Elixir, and attributed his repeated failures to the want of due preparation by pious and charitable acts. Whenever he wished to break an acquaintance or felt himself offended, he resented the supposed injuries by sending a present to the offender, and never seeing him afterwards: these presents sometimes consisted of an expensive chemical product or preparation. He had a heroic remedy for illness, which was a journey to Edinburgh and back by the mail-coach; and a cold taken on one of these expeditions terminated in inflammation of the lungs, of which he died.

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* Brande's *Journal of Science*, vol. ix. p. 237.

† Muirhead's *Origin and Progress of the Mechanical Inventions of James Watt*, vol. ii.

KELLERMAN.

In 1825 Sir Richard Phillips visited "an alchemist" named Kellerman, at the village of Lilley, between Luton and Hitchin. He was believed by some of his neighbours to have discovered the Philosopher's Stone and the Universal Solvent.

His room was a realisation of the well-known picture of Tenier's Alchemist. The floor was strewed with retorts, crucibles, alembics, jars, and bottles of various shapes, intermingled with old books.

Sir Richard proceeds to relate:

He gave me a history of his studies, mentioned some men in London whom I happened to know, and who, he alleged, had assured him that they had made gold. That having, in consequence, examined the works of the ancient alchemists, and discovered the key which they had studiously concealed from the multitude, he had pursued their system under the influence of new lights; and, after suffering numerous disappointments, owing to the ambiguity with which they describe their processes, he had at length happily succeeded; had made gold, and could make as much more as he pleased, even to the extent of paying off the National Debt in the coin of the realm.

Kellerman then enlarged upon the merits of the ancient alchemists, and on the blunders and impertinent assumptions of modern chemists. He quoted Roger and Lord Bacon, Paracelsus, Boyle, Boerhaave, Woulfe, and others, to justify his pursuits. As to the term Philosopher's Stone, he alleged that it was a mere figure to deceive the vulgar. He appeared to give full credit to the silly story of Dee's finding the Elixir at Glastonbury, by means of which, as he said, Kelly for a length of time supported himself in princely splendour. Kellerman added, that he had discovered the *blacker than black* of Apollonius Tyanus: it was itself "the powder of projection for producing gold."

It further appeared that he had lived in the premises at Lilley for twenty-three years, during fourteen of which he had pursued his alchemical studies with unremitting ardour; keeping eight assistants for superintending his crucibles, two at a time, relieving each other every six hours: that he had exposed some preparations to intense heat for many months at a time; but that all except one crucible had burst, and that, Kellerman said, contained the true "blacker than black." One of his assistants, however, protested that no gold had ever been found, and that no mercury had ever been fixed; for he was quite sure Kellerman could not have concealed it from his assistants; while, on the contrary they witnessed his severe disappointment at the result of his most elaborate experiments.*

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* *Personal Tour through the United Kingdom*, Part I., Nov. 1828. See "Secret of the Alchemists," *Things not generally Known*, p. 116; and "The Philosopher's Stone," *Popular Errors Explained*, p. 144.

DIALECT OF THE ALCHEMISTS.

The literal interpretation of the Hermetic treatises, and what may be termed their "Shibboleth," has probably led to Alchemy being overwhelmed with the reproaches of the modern world. Sometimes, in their dialect, man was designated as the Stone, antimony, lead, zinc, or arsenic; but they point to the means of his perfection, as animated mercury, the serpent, the green lion, shark, water, or virgin's milk. Figuier, speaking of this element, says that none of the alchemists have ever discovered it. The spirit of fire, transmuting all things, the salt of tartar, the spirit of wine driven to the centre by cold, and the essential salt of vipers, remain mysteries in the Hermetic dialects. Artephius wrote on antimony, but was illegibly obscure; and spoke of the salt of the sun and moon to be made homogene with other imperfect bodies of argent vive,—the water of life, azoth, and the true tincture. Basil Valentine adds the unicorn's horn, "the aguish magnetified needle."

If Bishop Berkeley knew what *Alcahest* meant, and if Kunckel was wrong in his application of a physical law to demonstrate its impossibility, it may be safely affirmed that no one has ever reduced to common sense the works of Geber the Arabian. Of course, the language of the Adepts was not designed for ordinary readers, being expressly designated as the magic language, and the language of angels. This, however, does not prove it to have contained any philosophy more practical than that which occupied itself in studying the secret of transmutation. What was of a mixed nature, between fixed and not fixed, and partook of a sulphurazurine? What was a raw, cooling, feminine fire? or the lustral water that cleansed the earth? Pure gold, violet, citrine, virgin's milk, purple, and transcendent redness, prove that, as Erynæus says, "this art is very cabalistical."

Grew thus points to the importance of gold in the art: "Every alchemist knows that gold will endure a vehement fire for a long time without any change; and after it has been divided by corrosive liquors into invisible parts, yet may presently be precipitated so as to appear in its own form."*

The students of the art were, however, told that under its enigmatical language was concealed the direction for a very easy and simple process. Raymond Lully remarks: "In the art of our magistery nothing is hid by the philosophers except the secret of the art, which it is not lawful for any man to reveal, and which, if it were done, he should be cursed, and should incur the indignation of the Lord, and should die of an apoplexy." The conclusion of Chaucer's "Chanon Yeoman's Tale" is much to the same purpose, except that the poet advises, since there is so great a secret, which is so by the especial providence of God, man shall not attempt to discover it. The Alchemists, on the contrary, say that it is only intended to be concealed from the profane; and that if any man by long study do attain to its knowledge, then to him it is revealed by the divine favour; and this mixture of religion and Alchemy will be found pervading every treatise on the subject. Hermes Trismegistus, in one of the treatises ascribed to him, directs the adept to catch the flying bird, and to drown it, so that it fly no more; by which is meant the fixation of quicksilver by a combination with gold. It is after this to be subjected to the action of *aqua regia*, by which its soul will be dissipated, and it will be united to the red eagle (muriate of gold). This is enigmatical, says Mr. Christmas, but it promises something. On the other hand, Elias Ashmole, who, if not himself a working alchemist, called the adept Backhouse "father," and studied Hebrew that he might fully illustrate the Hermetic philosophy, and the Philosopher's Stone,—has, in his *Theatrum Chemicum Britannicum*, preserved this fragment of banter:

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* Suidas maintains that the Golden Fleece, which Jason and the Argonauts (after a voyage through the Black Sea to Colchis) took, together with Medea, is not what the poets represent, but a treatise written on skins, teaching how gold might be prepared by chemistry; 'probably it was called *golden* by those who lived at that time on account of its great importance."

> I asked Philosophy how I should
> Have of her the thing I would.
> She answered me, when I was able
> To make the water malleable;
> Or else the way if I could find
> To measure out a yard of wind;
> Then shalt thou have thine own desire
> When thou canst weigh an ounce of fire:
> Unless that thou canst do these three,
> Content thyself thou gett'st not me.

Mr. Christmas describes a manuscript of the seventeenth century, in the Cambridge University Library, illustrated by coloured drawings of dragons, eagles, crucibles, and alembics; and speaking of the formation of precious stones, and implying the discovery of the second great object of the alchemist, viz. the Universal Solvent, or the Alkahest; the absurdity of which notion was exposed by Lavoisier. He inquired, *if the solvent were universal*, what vessel would hold it. The idea afforded only this one absurdity, that of supposing the solvent universal as to its effects. The experiments of Becquerel in France, and of Crosse in England, amply demonstrate that the operations of nature in the formation of minerals may, on a small scale, be performed by the electrician. The Alchemists did not expect to make diamonds, or even to make gold, out of that which was an essentially different substance. The baser metal was to be intrinsically purified; that terreous matter which caused it to differ from gold was to be "burnt and purged away," the fragments of the diamond were to be dissolved and reunited, or the ordinary flint was to be treated like the baser metal. The Ms. above quoted assumes also that the three great objects of the philosopher's search, namely, the transmuting agent, the universal solvent, and the universal remedy,—in other words, the Philosopher's Stone, the Alkahest, and the Elixir of Life,—were essentially the same body, causing by its purifying power the base and imperfect substance to cast aside its impurities, and exhibit itself in the most simple and perfect state, bringing back health and youth to the shattered constitution, and when pure, dissolving and decomposing all the bodies in order to exhibit them in a renovated and more complete form.*

The phenomena of life, death, and resurrection were illustrated by the language of Alchemy, the science of the period:

> We poor mortals (says Basil Valentine) are, for our sins here, by means of that death which we have well deserved, pickled in the earthly, that is, the kingdom of earth, till in process of time we become putrid and rot; and then are once more awakened, clarified, and sublimed by virtue of the heavenly fire and heat, even to the celestial sublimation and elevation; for all our dross, sins, and impurities are sundered from us.
>
> Luther, in his *Canonica*, praises Alchemy, "by reason of the glorious and fair resemblances which it has to the raising of the dead; for even as fire from each kind of thing doth extract that which is best, and doth sunder it from the bad, and thus doth carry the spirit itself upward, so that it shall have the upper place, whereas matter, like unto a dead body, doth remain below lying on the earth, so also will God, at the last day, sunder the godless and unrighteous from the righteous and godly. The righteous will ascend to heaven, but the unrighteous will abide below in hell.

In old diaries we find occasionally curious entries of the *arcana*. Aubrey relates that there lived at Wilton, in his day, one Mr. Boston, a Salisbury man, who was a great chemist, and did great cures by his art. But after long search for the Philosopher's Stone, he died at Wilton, having spent his estate. "After his death, they found in his laboratory there two or three baskets of *egge shelles*, which I remember Geber saith is a principall ingredient of that Stone."

The delusive character of the art has been cleverly epigrammatised. Libavius, whose name is more familiar as a chemist than as an adept, has this "rime" of *Alchemy:*

Alchymia est ars sine arte,
Cujus scire est pars cum parte,
Medium est strenue mentiri,
Finis mendicamentum iri.

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* *The Cradle of the Twin Giants, Science and History*, vol. ii.

The name of Alchemy has been applied to the modification of brass, supposed to have been occasionally formed by the Alchemist. Fletcher, in his *Purple Island*, c. vii., has

> Such were his arms, false gold, true alchemie.

Milton uses it for trumpet-metal:

> Four speedy cherubims
> Put to their mouths the sounding alchemy.
> *Paradise Lost*, ii. 517.

Minshull (*Essay*, p. 23) mentions "rings and chaines bought at St. Martin's,* that weare faire for a little time, but shortly after will prove alchemy, or rather pure copper."

The word alchemy was corrupted into *Occamy* or *Ockamy*, when it was applied to an imitation of silver. In Nash's *Lenten Stuffe* we read, "Pilchards are but counterfeit to herrings, as copper to gold, or ockamie to silver;" Steele, in the *Guardian*, No. 26, speaks of an *occamy spoon;* and the term is not yet quite disused among some classes. Johnson describes it as a "kind of mixed metal used for spoons and kitchen utensils."

Bacon, in his *Physical Remains*, however, distinguishes it thus: "white alchemy is made of pan-brass, one pound, and arsenicum, three ounces; or alchemy is made of copper and auripigmentum."

Alchemy was the science of this period; and hence, by degrees, alchemistical forms of expression for terrestrial processes passed into the language of ordinary life. The words *spirit of wine*, *spirit of salt*, *spirit of nitre*, and so forth, sufficiently bespeak a general belief in supernatural or occult agencies.

Ebenezer Sibly has published two quarto volumes on medico-astrological science; and speaks mysteriously, if not profoundly also, of alchemy; his reanimating Solar Tincture and his Lunar Tincture speak by their titles (*Christmas*). Of the same fraternity is Daffy's Elixir, from the *Elixir Vitæ*.

The chemistry of the Indians, embracing alchemistic arts, is called *rasâyana* (*rasa*, juice or fluid, also quicksilver; and *ayâna*, course or process), and forms, according to Wilson, the seventh division of the *âyur-Veda*, "the science of life, or the prolongation of life." (Royle, *Hindoo Medicine.*)

Gibbon, speaking of alchemy, says, that, "congenial to the avarice of the human heart, it was studied in China, as in Europe, with equal eagerness and with equal success. The darkness of the middle ages ensured a favourable reception to every new tale of wonder; and the revival of learning gave new vigour to hope, and suggested more specious arts of deception. Philosophy, with the aid of experience, has at length banished the study of alchemy; and the present age, however desirous of riches, is content to seek them by the humbler means of commerce and industry."—*Decline and Fall*, vol. ii.

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* St. Martin's-le-Grand was, until a very late period, noted for its manufacturers of counterfeit ware, as latten and copper articles, St. Martin's copper-lace, and occamy ware. In the adjoining Aldersgate and Cripplegate are, to this day, the principal refiners and workers of precious metals.

THE GOLDEN CHAIN OF HOMER.—THE HERMETIC OR MERCURIAL CHAIN.

Upon this famous wonder of the Ancients, we find in *Notes and Queries*, Second Series, Nos. 56, 57, and 58, by an anonymous Correspondent, a paper of extraordinary interest, the leading points of which we have condensed, selecting those which the more directly relate to Alchemy.

There exists a very curious book of Hermetic lore, entitled *Aurea Catena Homeri* (or, the Golden Chain of Homer), originally published in German, and translated into Latin by Dr. Favrat; for the loan of which when in Ms. 100 dollars were sometimes given, or for information concerning it. The author, who lived in the 17th century, was one Fuldang Leopold Codrus, who describes himself as a poor, persecuted ploughman and peasant.

The work may be in few words characterised as a treatise on the doctrine of a Graduated Chain of Nature, or Chain of Being, in two parts—(1) *Of the Generation of Things*, (2) *Of the Corruption of Things, and their Anatomy;* the author following the Egyptians and most ancient usages in regarding Nature as a Series of Rings, or Revolving Circles, forming a vast chain, which links the Deity with his humblest creatures. However, Codrus deals not so much with the Scale of Creatures as with the Protean Chain of Metamorphoses and Transmutations, which unites in one the Dyads or Bipolarities of Life and Death, Generation and Corruption, Corruption and Regeneration, Coagulation and Dissolution, Evaporation and Condensation, Volatilisation and Fixation, &c. Or, in the author's words, "How Nature herself dissolves and coagulates, resolves and regenerates. For what Nature makes, and by what means she makes it, through the very same means she destroys all again. Thus every thing has its Coagulator and Resolver, its Life and Death, within its own self, through which it is produced and sustained, and again broken up and destroyed. For from diversities of operation and of modes of operation proceeds a different working of effect."

In Part II. we have a curious passage on Transmutation, or expansion of the idea in the *Religio Medici*, as follows: "'All flesh is grass' is not only metaphorically but literally true; for all these creatures we behold are but the herbs of the field digested into flesh in them, or more remotely carnified in ourselves."—*Religio Medici.*

Coleridge, too, in the conclusion of his *Aids*, speaking of the magic metamorphoses wrought by the occult power of *Assimilation*, has this eloquent passage:

> The germinal power of the planet transmutes the fixed air and the elementary base of water into grass or leaves; and on these the organic principle in the ox or the elephant exercises an alchemy still more stupendous. As the unseen agency weaves its magic eddies, the foliage becomes indifferently the bone and its marrow, the pulpy brain, or the solid ivory, &c.—*Aids*, vol. i.*

A parallel to this doctrine may be found among the Burmese, who appropriately call the world "Logha," which signifies *alternate Destruction and Reproduction.* In Ovid (*Met.* lib. xv.) we have a good specimen of the old Egyptian philosophy on this head, as taught by Pythagoras.

The best and shortest summary that could be given of the contents of the *Aurea Catena Homeri* may be attained by quoting the following passage from an old Hermetic treatise, called *The Secret of Secrets*, ascribed to a certain King Kalid:—

> We have taught how a body is to be changed into a spirit, and again how the spirit is to be turned into a body, namely, how the fixed is made volatile, and the volatile fixed again: how the earth is turned into water and air, and the air into fire, and the fire into earth again: then the earth into fire, and the fire into air, and the air into water, and the water again into earth. Now the earth, which was of the nature of fire, is brought to the nature of a quintessence. Thus we have taught the ways of transmuting performed through heat and moisture; making out of a dry a moist thing, and out of a moist a dry one: otherwise natures which are of several properties or families could not be brought to one uniform thing, if (unless?) the one should be turned into the other's nature. And this is the perfection according to the advice of the philosopher. Ascend from the earth into heaven, and descend from heaven to the earth; to the intent to make the body which is earth into a spirit which is subtil, and then to reduce that spirit into a body again, which is gross: changing one element into another, as earth into water, water into air, air into fire; and that into a more subtil nature and quintessence. Thus have you accomplished the treasures of the whole world.†

The *Aurea Catena Homeri* derives its name from the celebrated passage at the beginning of the 8th book of Homer's *Iliad* (Cowper's translation), commencing thus:

* · Let ye down the *Golden Chain*
From Heaven, and pull at its inferior links
Both Goddesses and Gods.

The allusions to this Homeric Chain in old writers are very numerous. In *Paradise Lost* Chaos observes in his speech to Satan,

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* Coleridge, possibly, had in mind a passage in Herder's *Ideen.* book v. c. 3.

† These Transmutations remind one of the nursery-tale of *The Old Woman bringing her Kid to Market*, which Mr. Halliwell, in his work on Nursery Rhymes, traces to an allegoric-rabbinic parable of Transmutation.

> Now lately Heaven and Earth, another World,
> Hung o'er my realm, link'd in a *Golden Chain*
> To that side Heaven from whence your legions fell.
> *Book* ii. l. 1004.

And in the same book, l. 1050, Milton again alludes to it:

> And fast by, hanging in a Golden Chain
> This pendent World, in bigness as a Star
> Of smallest magnitude, close by the Moon.

The Golden Chain of Sympathy, this occult, all-pervading, all-connecting influence,* is the source of all Magic, and is called by a variety of names—such as, *The Vital Magnetical Series*, *Jacob's Ladder*, *Anima Mundi*, *Mercurius Philosophorum*, *the Magician's Fire*, &c. The Chain, as we find it in the most eminent philosophers, may be thus shortly concatenated: *Omnia et Uno, Omnia in Uno, Omnia ad Unum, Omnia per Medium, et Omnia in Omnibus.*

"Every thing," says Plato (*Protag.* 260), "resembles every other thing in some respect."

Thus, too, Hippocrates: "There is one conflux, one conspiration, and all things sympathise with all."

And Macrobius:

> There will be found, on a closer inspection, from the Supreme God down to the lowest dregs of things, one uninterrupted chain of connection, mutually binding them together.

Oswald Crollius, the Paracelsist, observes:

> *Plato's Rings and Homer's Chaines* are nothing but a Divine Series and Order serving Providence, a graduall and concatenate *Sympathy of things*. This visible and invisible Fellowship of Nature is that *Golden Chaine* so much commended, this is the marriage of heaven and riches, these are *Plato's Rings*, this is that dark and close Phylosophy so hard to be known in the most inward and secret parts of Nature, for the gaining whereof Democritus, Pythagoras, Plato, Apollonius, &c., have travelled to the Brachmans and Gymnosophists in the Indies, and to Hermes his pillars in Egypt. This was that which the most ancient Phylosophers studied, &c.—*The Admonitory Preface*, translated by Pinnell, 1657.

Sir Thomas Browne remarks:

> In a wise supputation, all things begin and end in the Almighty. There is a nearer way to Heaven than *Homer's Chain:* an easy logick may conjoin a heaven and earth in one argument, and, with less than a sorites, resolve all things to God. For though we christen effects by their most sensible and nearest causes, yet is God the true and infallible cause of all; whose concourse, though it be general, yet doth it subdivide itself into the particular actions of every thing, and is that

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* "That Magnetic Chain which is extended *a non gradu ad non gradum:* that Ladder of Celsus and of Zoroaster which reaches from Tartarus to the highest Heaven."—*Suggestive Inquiry into the Hermetic Mystery*, p. 338.

Spirit by which each singular essence not only subsists, but performs its operations.—*Religio Medici.*

Sir John Davies, in his noble poem on the Immortality of the Soul, thus speaks of "God's Eternal Law:"

Could Eve's weak hand, extended to the tree,
  In sunder rend that *Adamantine Chain,*
Whose *Golden Links, effects and causes* be;
  And which to God's own chair doth fixed remain.

Oh, could we see how cause from cause doth spring!
  How mutually they linked and folded are!
And hear how oft one disagreeing string
  The harmony doth rather make than mar!

The following passage is from a Treatise entitled *Schola et Scala Naturæ:*

Nature doth not lead thee towards God by a far-fetched and winding compass, but in a short and straight line. The *Sun* waits upon the *Rain*, the *Rain* upon the *Grass*, the *Grass* serves the *Cattel*, the *Cattel* serve *thee;* and if thou serve God, then thou makest good the highest Link in the Golden Chain, *whereby Heaven is joined to Earth;* then thou standest where thou oughtest to stand, in the uppermost round of the Divine Ladder, next to the Most High: then thou approvest thyself to be indeed what thou wert designed by God to be, the High-Priest and Orator of the Universe; because thou alone, amongst all the creatures here below, art endowed with understanding to know Him, and speech to express thy knowledge of Him in thy praises and prayers to Him.

The mystic Chain of Homer is called "golden" not merely as an epithet of eminence, but the term has an occult and peculiarly appropriate significance, especially in Hermetic works. In the first place, Gold was at once a Symbol of God and a Symbol of the Sun.

The Mystical Philosophers and Alchemists, generally speaking, regarded gold as a concretion or concentration of Light, or rather Fire. Van Helmont calls the Sun "a living and spiritual *Gold*, which (Gold) is a meer Fire, and beyond all, thoroughly refined *Gold.*" Barton, speaking of "the properties of *Elemental Fire* or *Æther*," quotes "an eminent philosoper and divine" to the same purpose: "Fire is the universal fountain of life, order, distinction, stability, and beauty of the universe. It is not only in the Sun and other heavenly bodies, but it makes part of every lump of matter upon and in our globe. . . . . . *Gold is no more than Mercury with abundance of Light or Fire in it*, as appears from an experiment. . . . . . So quick in its motions, so subtle and penetrating in its nature, so extensive in its effects, it seemeth no other than the *Vegetative Soul and Vital Spirit* of the world."—*The Analogy of Divine Wisdom*, 1750.*

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* See also J. Webster's *Metallographia;* or, a History of Metals; also the Handling and Showing of their Vegetability, and the Discussion of the most difficult Questions belonging to Mystical Chemistry, as of the Philosophers' Gold, their Mercury, the Liquor Alkahest, Aurum Potabile, and such like. 1761.

Moreover, Philo says:

> Those who praise Gold dwell on two especial points as most particularly important and excellent: one, that it does not receive poison; the other, that it can be beaten out or melted into the thinnest possible plates while still remaining unbroken. Therefore, it is very naturally taken as *an emblem of that Greater Nature,* which being extended and diffused every where, so as to penetrate in every direction, is wholly full of every thing, and also connects all other things with the most admirable harmony.—*On the Heir of Divine Things.*

Oswald Crollius says to the same effect:

> Nature is that medium which by an harmonicall consent joyneth the lowest things to the highest, and sometimes is called Animall, sometimes Vegetable, sometimes Minerall, according to the diversity of the subject or receptacle. Those who diligently seek out the Hermetic Phylosophy and the marvellous works of God, know that *that* same Spirit and minerall Nature which produceth Gold in the bowells of the earth is also in Man. That Spirit in Gold is the same with the Generating Spirit of all creatures, and is the same and onely Generative Nature, diffused through all things. This Spirit now hath assumed a Naturall body: It is that which first moveth and ruleth Nature in all naturall things, it preserveth all things, and all inferior things by a kind of harmonicall consent are governed by it. Albertus Magnus, in his Book of Mineralls, saith that gold may be found every where. There is not, saith he, that thing elementated of the Four Elements in which gold naturally may not be found in the last subtiliation thereof. And therefore the Phylosophers say that the Matter of their Mystery may be had every where, because it consisteth in every Elementated thing.

Gold has been always mystically connected with the Divine and Heavenly. Thus the Seven Heavens of the Hindoos (included with the natural heavens and the earth into one system) are surrounded by a broad circumference of gold. This Golden Circle is the symbol of the Sun's sphere, and understood spiritually, it is the Divine Love, surrounding and containing all. The Wedding Ring represents the same thing in miniature. Thus, too, with the Jews, among the sacred vestments of the High-Priest (which hieroglyphically represented the Universe), the Golden Breastplate was fastened to the Ephod by Golden Rings and Golden Chains; and the Ephod itself was girded on the High-Priest with a gorgeous cincture called the Golden Circle.

The Golden Chain of Homer is sometimes called the Hermetic or Mercurial Chain, from Hermes, or Mercury, among the Ancients being the personification of that pure Æther or invisible Fire which ensouls or concatenates all things in Nature: that Intellectual and Winged Spirit which illuminates, vivifies, and flashes through all things: that Universal Being or Plastic Spirit in Nature: that mysterious, all-pervading, all-constraining Magnetic Influence, which being itself One, unites in

One the Protean Forms of the Universe through which it passes,—that Informing, Unifying Spirit, of which Virgil speaks :—

> Principio cœlum, ac terras, camposque liquentes,
> Lucentemque Globum Lunæ, Titaniaque astra,
> Spiritus intus alit ; totamque infusa per artus
> Mens agitat molem, et magno se corpore miscet.—*Æn.* lib. vi.
>
> Know first that heaven and earth's compacted frame,
> And flowing waters, and the starry flame,
> And both the radiant lights, one common soul
> Inspires and feeds, and animates the whole.
> This active mind, infus'd through all the space,
> Unites and mingles with the mighty mass. *Dryden.*

Here, then, we have the *Mystic Fire* of the Eastern Sages, *the Astral Spirit in Man* of Paracelsus, the *Anima Mundi*, *the Golden Chain of Homer*, *the Mercury of the Philosophers*, *the Gold of the Alchemists*, *the Magical Quintessence*, for according to the old maxim, "All is in Mercury which the Wise men seek."

The remainder of the paper relates to the doctrine popularly known as "The Chain of Being."

In conclusion, we may observe, that within the last ten years has been printed in England a volume of considerable extent, entitled *A Suggestive Inquiry into the Hermetic Mystery*, London, T. Saunders, 1850. This work, which the Correspondent of *Notes and Queries* describes as "a learned and valuable book," is by a lady (anonymous), and has been suppressed by the author.

By this circumstance we are reminded of a concealment of alchemical practices and opinions, some thirty years since, when it came to our knowledge that a man of wealth and position in the metropolis, an *adept* of Alchemy, was held *in terrorem* by an unprincipled person, who extorted from him considerable sums of money under a threat of exposure.

Nevertheless, Alchemy has, in the present day, its prophetic advocates, who predict what may be considered a return to its strangest belief.

The nineteenth century has not yet passed away ; and Dr. Christopher Girtanner, an eminent professor of Göttingen, has prophesied, in a memoir on Azote, in the *Annales de Chimie*, No. 100, that it will give birth to the *Transmutation of Metals!* "In the nineteenth century," says the Professor, "the transmutation of metals will be generally known and practised. Every chemist and every artist will make gold : kitchen utensils will be of silver, and even gold, which will contribute more than any thing else to prolong life, poisoned at present by the oxides of copper, lead, and iron, which we daily swallow with our food."

ALCHEMICAL EXPERIMENTS ON THE TRANSMUTATION OF METALS.

In 1857, Dr. J. W. Draper, of New York, communicated to the *London Philosophical Magazine* the following remarkable and suggestive paper : "No one who has used a Tithonometer (for measuring the chemical action of light) can have failed to notice the disturbing effects of minute quantities of extraneous gases mingled with chlorine on photo-chemical induction. My attention has been directed to that subject in its more general aspect; and I will ingenuously confess that I have made several attempts at the transmutation of metals, on the principle of compelling them, by the aid of solar light, to be disengaged from states of combination in the midst of resisting or disturbing media.

The following is a description of these *alchemical attempts* In the focus of a burning-lens twelve inches in diameter, was placed a glass flask two inches in diameter, containing nitric acid diluted with its own volume of water. Into the nitric acid were poured alternately small quantities of a solution of nitrate of silver and of hydrochloric acid, the object being to cause the chloride of silver to form in a minutely divided state. so as to produce a milky fluid, into the interior of which the brilliant convergent cone might pass, and the currents generated in the flask by the heat might drift all the chloride successively through the light. The chloride, if otherwise exposed to the sun, merely blackens upon the surface, the interior parts undergoing no change : this difficulty I hoped, therefore, to avoid. The burning-glass promptly brings on a decomposition of the salt, evolving, on the one hand, chlorine, and disengaging a metal on the other. In one experiment the exposure lasted from 11 a.m. to 1 p.m. ; it was therefore equal to a continuous mid-day sun of seventy-two hours. The metal was disengaged very well. But what is it ? It cannot be silver, since nitric acid has no action upon it. It burnishes in an agate mortar, but its reflection is not like the reflection of silver ; it is yellower. *The light must therefore have so transmuted the original silver* as to enable it to exist in the presence of nitric acid. In 1837, I published some experiments on the nature of this decomposition in the *Journal of the Franklin Institute.*

Though this experiment, and several modifications of it, which I might relate, fail to establish any permanent change in the metal under trial, in the sense of an actual transmutation, it does not follow that we should despair of final success. It is not likely that nature should have made fifty elementary substances of a metallic form, many of them so closely resembling one another as to be with difficulty distinguished : moreover, chlorine and other elementary substances can be changed by the influence of sun-light, in some respects permanently; and if silver has not been thus far transmuted into a more noble metal, as platinum and gold, it has at all events been transmuted into *something which is not silver*. Those who will reflect a little on the matter cannot fail to observe that the sun's rays possess many of the powers once fabulously imputed to the Powder of Projection and the Philosopher's Stone."

ALCHEMY AND ASTROLOGY.

Rightly to appreciate and judge of the true nature of Alchemy, we must remember, that till the sixteenth century the earth was regarded as the centre of the universe, and that the life and destiny of men were believed to stand in the closest relation to the motions of the heavenly bodies. The universe was a vast whole, an organism, the members of which stood in an uninterrupted relation of reciprocal influence. "From all the ends of heaven the creative forces radiate towards the earth, and determine earthly destinies." (*Roger Bacon.*) "When a man," says Paracelsus, "eats a bit of bread, does he not therein consume heaven and earth, and all the heavenly bodies, inasmuch as heaven, by its fertilising rain, the earth by its soil, and the sun by his luminous and heat-giving rays, have all contributed to its production, and all are present in the one substance?" All that happened on earth stood written in starry characters in heaven. All that was thus written in heaven must of necessity happen on earth. Mars, Venus, or some other planet, rules from birth the actions and the fortunes of individual men; while comets, lawless in their appearance, were the threatening symbols of want and woe to entire nations.—*Liebig.*

TRANSITION FROM ALCHEMY TO CHEMISTRY.

When in the simple notions of the elements of the Alchemists—inflammability (sulphur), fixity (salt), and volatility (mercury)—men came to include the special qualities of inflammable, fixed, and volatile bodies, according as these were observed (oily, fat, earthy mercury; oily, fat, earthy, easily or difficultly inflammable sulphur; earthy, fusible, vitreous salt; inflammable, fat, oily, mercurial earth, &c.), then the significance of the original notion was lost. Becoming too wide and extended, it no longer included observed facts; and when Boyle searched after the sulphur, mercury, and salt of the Alchemists, these elements no longer existed. The idea was worn out. At a much later period, the notion of a suffocating property was designated by *sulphureous*, the combustion of a fixed body by *calcination*; that is, these things possessed one property in common with burning sulphur or with limestone (*calx*).

Hence it is no longer possible to give a definition of the terms "acid" and "salt" which shall include all those bodies which are called acids or salts. We have acids which are tasteless, and which do not redden vegetable blues, nor neutralise the alkalies; there are acids of which oxygen is an ingredient, and hydrogen is absent; others which contain hydrogen and no oxygen. The notion of a salt at last became so perverted, that chemists have gone so far as to exclude from the class of true salts, by their definition, common sea-salt, the salt of all salts, to which all others owe their very name.

We can readily see how easily a simple, defined notion becomes undefined by the addition of other notions. In the place of the worn-out ideas, we obtain, when we begin to distinguish, a number of new and more defined and separate ideas. It is even possible that the original idea, all but its name, may be lost; and the time may come when we shall no longer find an acid or a salt, just as we could not find the sulphur and mercury of the Alchemists, when these ideas were no longer necessary to science. Formerly their existence appeared obvious to every man; and they were only sought for when mankind had no further occasion for them.

Humboldt has the following comprehensive view of Alchemy, embodying a note by Kopp:

> The alchemistic opinions of the middle ages regarding the composition of metals, and the loss of their brilliancy by combustion in the open air (incineration, calcination), led to a desire of investigating the conditions by which this process was attended, and the changes experienced by the calcined metals, and by the air in contact with them. Cardanus, as early as 1553, had noticed the increase of weight that accompanies the oxidation of lead; and, perfectly in accordance with the idea of the myth of Phlogiston, had attributed it to the escape of a "celestial fiery matter" causing levity; and it was not until eighty years afterwards that Jean Rey, a remarkably skilful experimenter at Bergerac, who had investigated with the greatest care the increase of weight during the calcination of lead, tin, and antimony, arrived at the important conclusion that this increase of weight must be ascribed to the access of the air to the metallic calx. Rey, strictly speaking, only mentions the access of air to the oxides; he did not know that the oxides themselves (which were then called the earthy metals) are only combinations of metals and air. According to him, the air makes "the metallic calx heavier, as sand increases in weight when water hangs about it." The calx is susceptible of being saturated with air. Rey's work, indeed, contains the first approach to the better explanation of a phenomenon whose more complete understanding subsequently exercised a favourable influence in reforming the whole of Chemistry.
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> *Men had now discovered the path which was to lead them to the Chemistry of the present day;* and through it to the knowledge of the great cosmical phenomenon, viz. the connection between the oxygen of the atmosphere and vegetable life.—See *Cosmos,* vol. ii. pp. 729, 730.

Alchemy, says Liebig, is one of the three periods of Chemistry. In the first, all the powers of men's minds were devoted to acquiring a knowledge of the properties of bodies; it was necessary to discover, observe, and ascertain their peculiarities. This is the alchemistical period. The second embraces the determination of the mutual relations or connections of these properties; and this is the period of phlogistic chemistry. In the third period, in which we now are, we ascertain by weight and measure, and express in numbers, the degree in which the properties of bodies are mutually dependent. The inductive sciences begin with the substance itself; then come just ideas; and lastly, mathematics is called in, and with the aid of numbers completes the work.

ALCHEMY AND ALLOTROPISM.

The importance of Allotropism,* *i. e.* the existence of the same body under more than one form, is thus illustrated by Faraday: "In what does chemical identity consist? in what will the wonderful development of Allotropism end? whether the so-called chemical elements may not be, after all, mere allotropic conditions of fewer universal essences? whether, to renew the speculations of the Alchemists, the metals may be only so many imitations of each other, by the power of science mutually convertible? There was a time when this fundamental doctrine of the Alchemists was opposed to known analogies; *it is now no longer opposed to them, but only some stages beyond their present development.*"

Among the many scientific developments of late origin which tend to bring us back into speculations analogous with those of the Alchemists, is the relation between chlorine, iodine, and bromine. Already have we seen that it is possible for one body to assume, without combination, two distinct phases of manifestation; therefore, such of the so-called elements as are subject to Allotropism are not the unchanging entities they were once assumed to be; and now we find, after our attention has been led in the direction, that the triad of chlorine, bromine, and iodine not only offers a well-marked progression of certain chemical manifestations, but that the same progression is accordant with the numeral exponents of their combining weights. We seem here to have the dawning of a new light, indicative of the mutual convertibility of certain groups of elements, although under conditions which are as yet hidden from our scrutiny.

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* The term *Allotropism* is derived from two Greek words, corresponding, as nearly as they bear literal translation into English, with the expression *another state*, and is employed for the purpose of expressing the existence of certain bodies in conditions of manifestation different from those which they usually present, although their chemical composition remains the same.—*Faraday.*

The points or remarkable features of chlorine, iodine, and bromine may be thus sketched. Their dangerous activity when uncombined, their quietude when held in combination, the similarity of their qualities and functions, their gradation in colour and cohesion, and, more than all, the curious law which the consideration of their atomic weights unfolds,—these appear to be the especial features of this interesting triad of non-metallic elements.

Liebig, in his *Familiar Letters*, observes: In what a singular position do these facts place science of the present day, when compared with the opinions of the old philosophers and with Alchemy. The first taught that the properties of bodies were variable; and the Alchemists believed that all metals had in common a fundamental property, and that they were actually convertible. *We* show that two things, under certain circumstances, are one and the same, and that we can convert the one into the other as frequently as we choose.

One of the most remarkable examples of metamorphosis in the properties of a compound inorganic body has been discovered by Walter Crum, at Glasgow. He found that by continuous ebullition of acetate of alumina the salt was completely decomposed, and the acetic acid volatilised.

Alumina in its ordinary state is insoluble in water, very soluble in acids and alkalies, and absorbs colouring matters from solutions. But the modification of alumina discovered by W. Crum is soluble in water, is entirely precipitated from a watery solution by dilute acids and alkalies, and does not form lakes with decoctions of dye-woods, but is thrown down by them in a gelatinous, translucent form. Further, by concentrated acids and alkalies, the soluble alumina is again transformed into the insoluble.—*Appendix to Liebig's Letters.*

Faraday has this important conclusion:

The strange condition of Allotropism awakens within us an extraordinary train of speculation. There was a time, and that not long ago, when it was held amongst the fundamental doctrines of chemistry that the same body always manifested the same chemical qualities, excepting only such variations as might be due to the three conditions of solid, liquid, and gas. This was held to be a canon of chemical philosophy as distinguished from Alchemy; and a belief in the possibility of transmutation was held to be impossible, because at variance with this fundamental tenet. But we are now conversant with many examples of the contrary; and strange to say, no less than four of the non-metallic elements, namely, oxygen, sulphur, phosphorus, and carbon, are subject to this modification. Now if the condition of Allotropism were alone confined to compound bodies,—that is to say, bodies made up of two or more elements,—we might easily frame a plausible hypothesis to account for it; we might assume that some variation had taken place in the arrangement of their particles. But when a simple body, such as oxygen, is concerned, this kind of hypothesis is no longer open to us; we have only one kind of particle to deal with, and the theory of altered position is no longer applicable. In short, it does not seem possible to imagine a rational hypothesis to explain the condition of Allotropism as regards simple bodies. We can only accept it as a fact not to be doubted, and add the discovery to that long list of truths which start up in every science in opposition to our most cherished theories and long-received convictions.—*Lectures on the Non-Metallic Elements*, pp. 115-16.

LIEBIG ON THE CONNECTION OF ALCHEMY AND CHEMISTRY.

In our day (observes the great chemist of Giessen) men are only too much disposed to regard the views of the disciples and followers of the Arabian School, and of the late Alchemists, respecting transmutation of metals as a mere hallucination of the human mind, and, strangely enough, to lament it. But the idea of the variable and changeable corresponds with universal experience, and always precedes that of the unchangeable. Before the introduction of the balance, and the development of chemical analysis, there were no scientific grounds for the opinion that iron existed, as such, in a red stone, or copper in a blue or green stone, and were not produced by the processes followed for their extraction. If the metals were products, *i.e.* formed by the processes, and were not educts, *i. e.* already existing, and only separated by the process,—then were the metals capable of transmutation. Every thing depended on the process employed. The notion of bodies chemically simple was first established in the science by the introduction of the Daltonian doctrine, which admits the existence of solid particles not further divisible, or atoms. But the ideas connected with this view are so little in accordance with our experience of nature, that no chemist of the present day holds the metals, absolutely, for so many simple, undecomposable bodies, for true elements. Only a few years since Berzelius was firmly convinced of the compound nature of nitrogen, chlorine, bromine, and iodine; and we allow our so-called simple substances to pass for such, not because that we know they are in reality undecomposable, but because they are as yet undecomposed; that is, because we cannot yet demonstrate their decomposability so as to satisfy the requirements of science. But we all hold it possible that this may be done to-morrow. In the year 1807, the alkalies, alkaline earths, and earths proper, were regarded as simple bodies, till Davy demonstrated that they were compounds of metals with oxygen.

It is the prevailing ignorance of chemistry, and especially of its history, which is the source of the very ludicrous and excessive estimation of ourselves with which many look back on the age of alchemy; as if it were possible, or even conceivable, that for more than a thousand years the most learned and acute men, such as Francis Bacon, Spinosa, and Leibnitz, could have regarded as true and well founded an opinion void of all foundation. On the contrary, must we not suppose, as a matter beyond a doubt, that the idea of the transmutability of metals stood in the most perfect harmony with all the observations and all the knowledge of that age, and in contradiction to none of these?

In the first stage of the development of science, the Alchemists could not possibly have any other notions of the nature of metals than those which they actually held. No others were admissible, or even possible; and their views are consequently, by natural law, inevitable. We hear it said that the idea of the Philosopher's Stone was an error; but all our views have been developed from errors, and that which to-day we regard as truth in chemistry may perhaps before to-morrow be recognised as a fallacy.

Almost every word in a Manual of Chemistry expresses an observation or a phenomenon. These observations did not present themselves to the observer; they were laboriously sought for and obtained. What would be the present position of science without sulphuric acid, which was discovered by the Alchemist more than a thousand years ago; without muriatic acid, nitric acid, ammonia, the fixed alkalies, the numberless compounds of metals, alcohol, ether, phosphorus, or Prussian blue? It is impossible to form a just conception of the difficulties which the Alchemists had to overcome in their researches; for they were of necessity the inventors of the apparatus or instruments, and of the processes, which served for the production of their preparations; and they were compelled to make with their own hands every thing which they employed in their experiments.

Alchemy, Liebig maintains, was never at any time any thing different from Chemistry. It is utterly unjust to confound it with the gold-making of the 16th and 17th centuries. Among the Alchemists there was always to be found a nucleus of genuine philosophers, who often deceived themselves in their theoretical views; whereas the gold-makers, properly so-called, knowingly deceived both themselves and others. Alchemy was a science, and included all those processes in which chemistry was technically applied. The achievements of such alchemists as Glauber, Böttger, and Kunckel in this direction may be boldly compared to the greatest discoveries of our century.*

The dreams of the Alchemists (says Sir John Herschel) led them in the path of experiment, and drew attention to the wonders of Chemistry, while they brought their advocates (it must be admitted) to merited contempt and ruin. But in this case it was moral dereliction which gave to ridicule a weight and power not necessarily or naturally belonging to it. But among the Alchemists were men of superior minds, who reasoned while they worked, and who, not content to grope always in the dark, and blunder on their subject, sought carefully in the observed nature of their agents for guides in their pursuit. To these we owe the creation of experimental philosophy.

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* Selected and abridged from Liebig's *Familiar Letters on Chemistry*, Fourth Edit., 1859.

EARLY EGYPTIAN CHEMISTRY.

In 1852, Mr. W. Herapath, of Old Park, whilst unrolling a mummy at the Bristol Institution, found on three of the bandages hieroglyphical characters of a dark colour, as well defined as if written with a modern pen. Where the marking-fluid had flowed more copiously than the characters required, the texture of the cloth had become decomposed, and small holes had resulted. Mr. Herapath had no doubt that the bandages were genuine, and had not been disturbed or unfolded. The colour of the marks was so similar to that of the present "marking ink," that Mr. Herapath was induced to try if they were produced by silver. With the blowpipe he immediately obtained a button of that metal; the fibre of the linen he proved by the microscope and by chemical reagents to be linen. It is therefore, he adds, certain that the ancient Egyptians were acquainted with the means of dissolving silver, and of applying it as a *permanent ink;* but what was their solvent? I knew of none that would act upon the metal, and decompose flax-fibre but nitric acid, which, we are told, was unknown until discovered by the Alchemists in the 13th century, which was about 2200 years after the date of this mummy, according as its superscription was read. A very probable speculation might be raised upon this to account for the solution of the Golden Calf by Moses, who had all his mundane knowledge from the Egyptian priests. It has been supposed that he was acquainted with and used the sulphuret of potassium for that purpose: how the inference arose, I know not. But if the Egyptians obtained nitric acid, it could only have been by the means of sulphuric acid, through the agency of which, and by the same kind of process, they could have separated hydrochloric acid from common salt. It is therefore more probable that the priests had taught Moses the use of the mixed nitric and hydrochloric acids, with which he could dissolve the statue, rather than with a sulphuret, which we have no evidence of their being acquainted with.

The yellow colour of the fine linen cloths, which had not been stained by the embalming materials (says Mr. Herapath), I found to be the natural colouring matter of the flax. The Egyptians therefore, if we judge from this specimen, did not practise bleaching. There were in some of the bandages, near the selvage, some twenty or thirty blue threads: these were dyed by indigo; but the tint was not so deep nor so equal as the work of the modern dyers; the colour had been given it in the skein. One of the outer bandages was of a reddish colour, which dye I found to be vegetable, but could not individualise it. My son, Mr. Thornton Herapath, analysed it for tin and alumina; but could not find any. The face and internal surfaces of the orbits had been painted white, which pigment I ascertained to be finely powdered chalk.

To the above views Mr. Denham Smith has objected, inasmuch, he says, as there is no evidence to prove the Egyptians were ever acquainted with the art of distillation.

Mr. Thornton Herapath next examined with a microscope the stained fibres of the bandage; and on making comparative experiments with a piece of the linen wrapper, recently "marked" in the usual way with a solution of nitrate of silver, the fibre presented a very similar appearance to that of the ancient stained cloth. Hence it is concluded that the Egyptians were really acquainted with nitric acid, and employed the nitrate of silver as a marking-fluid. In this view Dr. W. Camps has also coincided, in a paper read to the Syro-Egyptian Society. "If," adds the Doctor, "this were admitted, we must then allow the Egyptians to have had a more intimate acquaintance with chemistry and chemical preparations than is generally assigned even to these very clever, intelligent, and ancient people."

The Egyptian looms were famed for their fine cotton and woollen fabrics; and many of these were worked with patterns in brilliant colours, which on dresses worn by women were very varied. They were mostly worked with the needle; but some were woven in the piece. Of these last were the linen and cotton fabrics with blue borders, the threads having been previously dyed with indigo; and stripes, or some other simple devices, were generally put into the stuff on the loom. Some of the stripes were of gold thread, alternating with red lines as a border. It was also usual to embroider patterns in the staircase style common in our worsted-work; and some were made out with long stitches that laid down the figures or devices on the surface. Some of these are in the Louvre. They are mostly cotton; and although their date is uncertain, they suffice to prove that the manufacture was Egyptian; and the many dresses painted on the monuments of the eighteenth dynasty show that the most varied patterns were used by the Egyptians more than 3000 years ago, as they were at a later period by the Babylonians, who became noted for their needlework.

The Egyptians had also the secret of dyeing cloths of various colours by means of mordants—a fact satisfactorily proved by the very manner in which Pliny describes a process which he evidently did not understand.—Sir Gardner Wilkinson, *The Egyptians in the time of the Pharaohs.*

Modern Chemistry.

THE GREAT AGENTS OF CHANGE.

These are gravitation, cohesion, motion, chemical force, heat, and electricity, which must, from that hypothetical time when the earth floated a cloud of nebulous vapour in a state of gradual condensation, up to the present moment, have been exercising their power and regulating the mutations of matter.—*Hunt's Poetry of Science.*

The quantity of work produced by chemical force is in general very great. A pound of the purest coal gives, when burnt, sufficient heat to raise the temperature of 8086 pounds of water one degree of the centigrade thermometer. From this we can calculate that the magnitude of the chemical force of attraction between the particles of a pound of coal and the quantity of oxygen that corresponds to it, is capable of lifting a weight of one hundred pounds to a height of twenty miles. Unfortunately, in our steam-engines we have hitherto been able to gain only the smallest portion of this work, the greater part being lost in the shape of heat. The best expansive engines give back as mechanical work only eighteen per cent of the heat generated by the fuel.—*Professor Helmholtz.*

IMPERFECTION OF CHEMISTRY.

The phenomena of chemistry are still more complicated than those of the science of the stars. Indeed, chemistry is still so far from perfection that the chemist cannot construct a particle of sugar or any other organic substance, although he knows the exact quantities of charcoal and water of which it is composed.

WHAT IS APPLIED CHEMISTRY?

A knowledge of the composition of bodies, which enables chemists to solve questions which a few years ago were supposed to be beyond their powers. The discovery of the composition of soils and of the ashes of plants enables them to see the reason why one and the same plant, grown without manure in the same soil for three, another for seven, ten, or more years, at length cease to flourish on it; why one field produces wheat, but not beans; barley, but not tobacco; and why from another a rich crop of turnips, but no clover is obtained. Chemistry explains the operation of manures, and teaches the mode of restoring fertility to an exhausted soil. This is Applied Chemistry.

Hitherto scarcely any demand has been made upon the science of chemistry by arts, manufactures, or physiology which has not been responded to. Every question clearly and definitely put has been satisfactorily answered. Only when the inquirer had no precise idea of the problem to be solved has he remained unsatisfied.

Chemistry is the foundation of agriculture, and we cannot hope to give a scientific form and basis to this important art without a knowledge of the constituents of the soils and of the substances which constitute the food of plants. Yet the chemist was not able until lately to decompose water, and he still labours in vain to build up, out of water, carbon, and atmospheric air, most of the precious compounds which the as yet mysterious actions of vegetable and animal life present to us. He cannot yet chemically make opium, or wheat-flour, or sugar; but progress is being made in that direction, for he not only knows that the foul, horribly offensive water which has served to wash or purify coal-gas at the gas-works contains the elements of lavender, camphor, attar of roses, and other perfumes, but he can now extract a near approximation to some of them; and, strange to say, he can now produce by his art the exquisite flavour of the strawberry and pine-apple, in any climate or scene, without aid from garden-beds or sunshine.

THE GREAT DISCOVERIES IN CHEMISTRY.

Dr. Neil has thus grouped these invaluable aids to civilisation.

A century ago no person on earth knew that there existed in nature the substance which, since Dr. Priestley's discovery of it in 1774, has been named *Oxygen* (so named because of its early perceived relation to acids), although now students soon learn that it forms a large proportion, by weight, of a majority of the things—whether solid, liquid, or aëriform, living or dead—which men have yet encountered on this globe.

Nor did any one then know that Water is a compound of eight parts by weight of this oxygen and one part by weight of another element, called *Hydrogen* (so called because of its relation to water); both of which elements, when in their separate or insulated state, and at the temperature of the earth, exist in the form of air or gas, and might therefore serve as stuffing for air-cushions. Hydrogen is now popularly known as the chief material burned in our street-lamps, and as what, being very light, is used for filling balloons.

Nor was it known that all vegetable bodies—whether wood, leaves, or flowers, or fruit or seed—consist chiefly of these two elements of water combined in different proportions with another elementary substance, which has got the name of *Carbon* (so called because it was first known as being the chief part of coal).

Nor was the truth suspected that animal flesh, and soft animal substances generally, consist chiefly of the three component parts of vegetables just named, with the addition of a fourth, called *Nitrogen* (so called because first obtained from nitre); which last, when existing separately, also appears as an air or gas, and which, when mixed with one-fourth part by weight of oxygen, forms our common atmospheric air.

Nor were people aware that the whole of the countless variety of the material substances, including minerals, yet known to man are compounds of a very few simple elements; of these the four above spoken of are a very important portion, joined, atoms to atoms, in different proportions and ways, somewhat as all the words in all the languages used on earth are composed of a few simple sounds recalled by the letters of a general alphabet; which atomic elements, while in themselves absolutely unchangeable and indestructible, assume in combination or alone the three forms of solid, liquid, or gas, according to the quantity of heat pervading them.

Nor, lastly, was it known that the heat and light accompanying rapid combustion are effects of the intensity of action with which two or more combining substances are at the moment uniting into chemical compounds, one of the burning substances generally being oxygen; the same substance, however, being also capable, under other circumstances, of combining slowly and quietly, with scarcely sensible increase of temperature, and no light, as when the oxygen of the air is combining with exposed iron and converting it gradually into rust.

IMPROBABILITY OF FAMINES.

Those frightful famines by which Europe used to be ravaged several times in every century have ceased (in the 11th, 12th, and 13th centuries, the average was, in England, one famine every fourteen years); and so successfully have we grappled with famines, that there is not the slightest fear of their ever returning with any thing like their former severity. Indeed, our resources are now so great, that we could, at worst, only suffer from a slight and temporary scarcity; since, in the present state of knowledge, the evil would be met at the outset by remedies which chemical science could easily suggest. Sir John Herschel and Cuvier consider famine, in the present state of chemistry, "next to impossible."

NOTHING LOST IN THE WORLD.

Throughout the changes which are constantly taking place in the substance of our globe, and in the living inhabitants of its surface, *one thing remains unchanged*—the absolute quantity of each of the elementary forms of matter; for whatever may be the new chemical combinations into which they enter, whatever the new physical arrangements to which they are subjected, their aggregate is the same now as it was at first. The researches of modern chemistry have most clearly established that the annihilation of matter is as impossible to man as its creation; and that in every instance in which such a destruction seems to be effected, there is in fact nothing but a change of form. Thus, in every act of ordinary combustion, the disappearance of the combustible is simply due to the formation of new compounds between its elements and the oxygen of the air, and to the diffusion of these compounds through the atmosphere; the decay of organised bodies being merely a slower kind of combustion, whose products are essentially the same in kind, and are disposed of in like manner. When we inquire into the nature and origin of either class of substances, we find that this dissemination of their materials through the atmosphere merely restores to it what was originally taken from it by the agency of living beings; thus completing a cycle of most marvellous nature.—*National Review*, No. 8.

WHAT IS AN ELEMENT?

Mr. Faraday, in his admirable Lectures on the Non-metallic Elements, says: "Let me remark that the word 'Element' is only to be accepted in a provisional sense. Chemists are not without a hope—a hope that we trust is not irrational—of being enabled to effect changes on some of these so-called elementary forms. The phenomena of allotropism seem to afford rational ground for this hope; and thus we are unconsciously brought back into tracks of thought and action having some similitude to the doctrines of alchemy;—similar, though not identical; not the transmutation of base metals into gold, but transmutation nevertheless of a certain kind.

In pursuing this field of speculation, there is reason to believe we should derive much information as to the intimate nature of these non-metallic elements, if we could succeed in obtaining hydrogen and nitrogen in the liquid or solid form. Many gases have been liquefied: one, carbonic-acid gas, has been solidified; but hydrogen and nitrogen have resisted all our efforts of this kind. Hydrogen, in many of its relations, acts as though it were a metal; could it be obtained in a liquid or solid condition, the doubt might be settled. This great problem, however, has yet to be solved; nor should we look with hopelessness on this solution, when we reflect with wonder, and, as I do, almost with fear and trembling, on the powers of investigating the hidden qualities of these elements—of questioning them, making them disclose their secrets and tell their tales—given by the Almighty to man!"

Dr. George Wilson has thus stated the case: "Our globe, including the atmosphere, and the ocean with its tributary waters, consists, in very unequal proportions, of some sixty-three substances, which, according to our present knowledge, are simple or elementary. Of these chemical elements, less than a third are found distributed throughout the entire Vegetable and Animal Kingdoms. Of this fractional third, one-half occur only in small quantity, so that the *greater* part of the bulk and weight of plants and animals is made up of one-fifth or one-sixth of the whole elements; and the *greatest* part consists but of three, carbon, hydrogen, and oxygen."

"THE ONE ELEMENT."

Curious relations (says Mr. Hunt), which can be traced through certain bodies, lead us to believe that they may be only modified conditions of one element. Flint and charcoal do not at first appear allied; but carbon, in some of its states, approaches very near to the condition of silicon, the metallic base of flint. When we remember the differences which are evident in three forms of one body—coke, graphite, and diamond,—the dissimilitude between flint, a quartz crystal, and carbon will cease to be a strong objection to the speculation. —*Poetry of Science.*

In 1842, Mr. Grove said, in a lecture at the Royal Institution: "Light, heat, electricity, and magnetism, motion and chemical affinity, are all convertible material affections: assuming any one as a cause, one of the others will be the effect. Thus heat may be said to produce electricity, electricity to produce heat; magnetism to produce electricity, electricity magnetism; and so of the rest. Cause and effect, therefore, in their relation to such forces, are words solely of convenience; we are totally unacquainted with the generating power of each and all of them, and probably shall ever remain so. We can only ascertain the normal of their action; we must humbly refer their causation to one Omnipresent influence, and content ourselves with studying their effects, and developing by experiment their mutual relations."

"I have long held an opinion," said Mr. Faraday in 1845, "almost amounting to conviction, in common, I believe, with many other lovers of natural knowledge, that the various forms under which the forces of matter are made manifest have a common origin, or, in other words, are so directly related and mutually dependent, that they are convertible one into another."

MATERIALS OF THE GLOBE.

The metallic elements constitute a large majority of the whole, only thirteen of the sixty-three being non-metallic; and from within the limits of this narrow range of only sixty-three has Omnipotence selected the materials which compose our globe, and the living beings which inhabit it; out of these all the diversified forms and beings of the world are made. From the dense masses of rocks and mountains amongst inanimate things, to the fleeting atmosphere which surrounds us; from the simpler forms of animal or vegetable life to the most highly organised, however different one from another in aspect or in functions, —they have all been created out of these elements in the sixty-three. Nor is this all. By a wonderful power of adaptation, which bespeaks Omnipotence, our earth and its inhabitants are not made up of these sixty-three bodies equally distributed, but by far the greatest portion of terrestrial matter is composed of the thirteen non-metallic elements; and, yet more strange, nearly two-thirds of the whole material terrestrial universe, organic and inorganic, are composed of one alone of these simple non-metallic elements—OXYGEN. How great, then, must be the power of adaptation imposed on these elements, by which they are made to discharge so many functions, and to appear under so many different forms!—*Faraday.*

An acute writer in the *National Review*, No. 8, has thus illustrated this view: "When the term of the existence of vegetation, either wholly or in part, has been completed, if air be partially secluded, the process of decay is less complete; various new compounds are formed, which are rich in carbon and hydrogen, but poor in oxygen, and are therefore eminently combustible: yet these have a character of permanence which indisposes them to spontaneous change; and the products of the partial decay of a past vegetation may remain stored up in the depths of the earth for an unlimited period, until the ingenuity of man turns them to his own account. There are comparatively few to whom it occurs, when they are warming themselves over the winter-fire, or watching the fuel thrown into some vast steam-engine, that the combustion that cheers them by its genial glow, or generates a power of a thousand horses, is giving back to the atmosphere, in the form of carbonic acid and water, the identical carbon and hydrogen which were drawn from it by the luxuriant vegetation of the primeval world. Yet nothing is more certain than that all coal was once air, and that it was the flora of the carboniferous period which solidified it."

HARMONY OF CREATION.

The world with its ponderable constituents, dead and living, is made up of natural elements, endowed with nicely-balanced affections, attractions, or forces. Elements the most diverse, of tendencies the most opposed, of powers the most varied,—some so inert, that, to a casual observer, they would seem to count for nothing in the grand resultant of forces; some, on the other hand, endowed with qualities so violent, that they would seem to threaten the stability of creation; yet when scrutinised more narrowly, and examined with relation to the parts they are destined to fulfil, all are found to be accordant with one great scheme of harmonious adaptation. The powers of not one element could be modified without destroying at once the balance of harmonies, and involving in one ruin the economy of the world!

Look, for example, at the shells of sea mollusca: nearly one-half of their weight is carbonic acid. Gradually it has been collected from the surrounding medium, has pervaded the systems of these delicate creatures, has circulated in their fluids, has combined with lime, and finally been deposited by their mantles in the form of a shell. Had carbonic acid been corrosive, this could not have been. Carbonic acid would have, in that case, become totally unadapted to the performance of its destined end.—*Faraday.*

COMPENSATING FORCES IN CREATION.

Dr. Maury thus strikingly illustrates the admirable system of compensation, and the beauty and nicety with which things and principles are meted out in directions apparently the most opposite, but in proportions are exactly balanced. Thus, by the action of opposite and compensating forces, the earth is kept in its orbit, and the stars are held in suspension in the azure vault of heaven; and these forces are so exquisitely adjusted, that, at the end of a thousand years, the earth, the sun, and moon, and every star in the firmament, is found to come and stand in its proper place at the proper moment.

When the little snowdrop was created, the whole mass of the earth, from pole to pole, and circumference to centre, must have been taken into account and weighed, in order that the proper degree of strength might be given to its tiny fibres.

NUMBERS IN NATURE.

Physical Science shows that numbers have a significance in every department of nature.

Two appears as the typical number in the lowest class of plants, and regulates the pairing or marriage of plants and animals.

Three is the characteristic number of that class of plants which has parallel veined leaves, and is the number of joints in the typical digit.

Four is the significant number of those beautiful crystals which show that minerals as well as stars have their geometry.

Five is the model number of the highest class of plants, with reticulated veins and branches; is the typical number of the fingers and toes of vertebrate animals, and is of frequent occurrence among star-fish.

Six is the proportion number of carbon in chemistry, and 3 × 2 is a common number in the floral organs of monocotyledonous plants, such as lilies.

Seven appears as significant only in a single order of plants (*Heptandria*); but has an importance in the animal kingdom, where it is the number of vertebræ in the neck of mammalia; and, according to Edwards, the typical number of rings in the head, in the thorax, and in the abdomen of crustacea.

Eight is the definite number in chemical composition for oxygen, the most universal element in nature, and is very common in the organs of sea-jellies.

Nine seems to be rare in the organic kingdom.

Ten, or 5 × 2 is found in star-fishes, and is the number of digits in the fore and hind limbs of animals.

Without going over any more individual numbers, we find multiple numbers acting an important part in chemical compositions and in the organs of flowers; for the elements unite in multiple relations, and the stamens are often the multiples of the petals. In the arrangement of the appendages of the plant we have a strange series, 1, 2, 3, 5, 8, 13, 21, 34, which was supposed to possess virtues of an old date, and before it was discovered in the plant. In natural philosophy, the highest law, that of forces acting from a centre, proceeds according to the square of numbers. In the curves and relative length of branches of plants there are evidently quantitative relations which mathematics has not been able to seize and express.

UNITY OF THE DEITY.

In examining the human structure, and comparing it with that of animals in general, a new and grand evidence has been afforded of the unity of the Divine action; supplying the last argument required, and left untouched by the famous Cudworth, to refute the old atheistic doctrine of Democritus and his followers, who, it will be remembered, resolved the existence of men and animals into the fortuitous concourse of atoms—by demonstrating the existence, in the Divine mind, of pattern, or plan, prior to its manifestation in the creation of man. "The evidence of unity of plan in the structure of animals testifies to the oneness of their Creator, as the modifications of the plan for different modes of life illustrate the beneficence of the designer."*

Man is no longer regarded as though he were distinct in his anatomy from all the rest of the animal creation; but his structure is perceived to be an exquisite modification of many other structures, the whole of which have been now recognised as modifications of one and the same general pattern. Every one of the 260 bones which may be enumerated in the human skeleton can be unerringly traced in the skeletons of many hundred inferior animals; and the human anatomist of our day begins to comprehend the nature of his own structure in a way never dreamed of by his predecessors.—*S. Warren's Lecture on Intellectual and Moral Development of the present Age.*

Nearly sixty years since Paley wrote: "Of the unity of the Deity, the proof is the uniformity of plan observable in the system," bespeaking "the same creation and the same Creator;" almost prophetic words, which have been so strikingly illustrated by the superior science of the present day.

WHAT IS ATMOSPHERIC AIR?

The term Atmospheric Air conveys to the mind of the chemist the idea of a number of properties. No mortal eye has ever seen a particle of air; for sight presupposes a certain effect produced on the eye, which particles of air are quite incapable of producing. They possess, however, other properties, which chemistry brings to view, and by which the chemist not only ascertains their presence when they escape the notice of others, but he is also enabled by them to show that this invisible, impalpable material consists of several other equally invisible substances. By his exact knowledge of the properties, he can separate them from each other, weigh them, and make their presence manifest to others. He is able to show that the air which burns in our street-lamps consists of five or six totally different airs. He points out, in a constituent of atmospheric air, employed in respiration, one of the most indispensable requisites for animal life; and in a product of respiration, one equally important to vegetable life. He exhibits the intimate connection between the visible and invisible material world, of the existence of which our ancestors had no idea. He is enabled to do all this by his knowledge of the peculiar properties of these bodies, acquired by the means of visible phenomena, or such as can be recognised by the senses. He must first bring these substances in contact with others to render these phenomena manifest; but when he has done this, they then become more distinct than the tones of a chord when struck, and as intelligible as the black lines and characters which convey to a far distant friend our invisible thoughts.—*Liebig's Familiar Letters.*

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* See the *Archetype and Homologies of the Vertebrate Skeleton*, &c., by Richard Owen, F.R.S.

CHEMICAL COMPOSITION OF THE ATMOSPHERE.

When we reflect upon the number of gases and vapours that are disengaged on the surface of the globe from all the decompositions of the great animal and vegetable kingdoms, together with all the poisonous matter of infectious disease, we might expect, at least, to find a long list of elements in the analysis of the atmosphere. But not so. Oxygen, nitrogen, vapour of water, and a small fraction of carbonic-acid gas, are all at present detected. This is the same in town or country, on the plain or the mountain-top; or perhaps it would be more correct to say, chemistry is not yet sufficiently advanced to detect the difference. Surely the air that sweeps the Pontine marshes, branding the native of that treacherous climate with the appearance of age in his youth, or that air which surrounds the pallid sedentary mechanic in the densely populated city, cannot be the same which gives the sailor and the rustic farmer such a ruddy countenance. Therefore, at present, the best test of the purity of an atmosphere is its effect on the constitution. In 100 parts of atmospheric air there are twenty-three parts of oxygen gas, and seventy-seven of nitrogen (Dumas and Boussingault). The quantity of carbonic-acid gas is variable : from the mean of various experiments it exists in the proportion of one volume in 2000 of atmospheric air. This proportion is greater near the level of the sea in summer than in winter, and greater during the night than during the day, and rather more abundant on the summit of mountains than on the plains.—*Journal of Public Health.*

DAVY'S EARLY DREAM.

Humphry Davy, when nineteen summers old, among other things, concluded that oxygen, as it exists in the atmosphere, is a compound of real oxygen and a matter of light ; that when a taper burns, this light is set free, while the wax unites with the actual oxygenous principle of oxygen, and melts "into thin air." That when a man inspires, this "phos-oxygen" (such was the name he put upon the ordinary oxygen of the atmosphere) is absorbed by the blood, carried to the brain, and there decomposed into true oxygen and light; and that the light thus liberated within the most intimate recesses of "the golden bowl," from which the stream of higher life appeared to permeate the body, is the nervous energy, and the proximate cause of sensation, perception, and emotion. In sad and sober truth, the enthusiast was then a materialist; and this dazzling vision, which sanctified the divinity of nature to his kindled imagination, was a compromise between his impersonal piety and the eminently practical but brilliant science by which he was taken captive.—*North British Review*, No. 3.

MATERIALITY OF HEAT.

How much the progress of science depends on the mode in which phenomena are interpreted by the first observers, is strikingly illustrated in the case of certain experiments of Robert Boyle. He observed that when copper, lead, iron, and tin were heated to redness in the air, a portion of calx was formed, and there was a constant and decided increase of weight. (*Experiments to make Fire and Flame ponderable*, 1673.) This experiment he repeated with lead and tin in glass vessels hermetically sealed, and found still an increase of weight; but observed further that when the "sealed neck of the retort was broken off, the external air rushed in with a noise." (*Additional Experiments*, No. v.; *and a Discovery of the Perviousness of Glass to ponderable parts of Flame*, exp. iii.) From this he reasoned correctly, that in calcination the metal lost nothing by drying up, as was generally supposed, or that if it did, "by this operation it gained more weight than it lost." (*Coroll.* ii.) But this increase of weight he attributed to the fixation of heat, stating it as "plain that igneous particles were trajected through the glass," and that "enough of them to be manifestly ponderable did permanently adhere." Had he weighed the sealed retort before he broke it open, he must have concluded that the metal had increased in weight at the expense of the enclosed air. He stood, in fact, at the very brink of the Pneumatic Chemistry of Priestley; he had in his hand the key to the great discovery of Lavoisier. How nearly were these philosophers anticipated by a whole century, and the long interregnum of phlogiston prevented! On what small oversights do great events in the history of science, as of nations, depend! —*Prof. Johnstone, Proc. British Assoc.* vol. vii.

CHEMICAL AGENCIES OF LIGHT.

In by far the larger number of cases in which light is evolved, its manifestations can be directly traced to chemical combinations; whilst, conversely, light is often a most powerful agent in bringing about chemical change. In fact, it may be doubted whether light does not alter the structure or composition of all matter through which it passes, or on which it falls. Upon such an alteration depend not only all the phenomena of photography, and numerous chemical changes of a most important character, but also the sustentation of all organic life and our own sensibility to visual phenomena For it is by the extraordinary influence of light upon the surface of the growing plant, that it is able to separate the inorganic elements of water, carbonic acid, and ammonia, and to unite them into those new and peculiar compounds—starch, oil, albumen, and their derivatives, which serve not only for the extension of the vegetable fabric, but also for the nutrition of the animal body; so that without light, as Lavoisier truly said, nature were without life and without soul. That the influence of light is exerted in providing the material for vegetable growth by quasi-chemical action, is capable of proof by the direct experiment, that, *ceteris paribus*, the quantity of carbonic acid decomposed by a plant in a given time is proportioned to the amount of light that has fallen upon it.—*National Review*, No. 8.

EFFECT OF COLOURED LIGHT ON GERMINATION.

Mr. Lawson of Edinburgh has been accustomed to ascertain the commercial value of seeds by experimental germination, and so to determine their value in the market. The process ordinarily occupies from twelve to fifteen days; but Mr. Lawson found that by using *blue glass* he was enabled to determine the value of the seeds in two or three days, which is to him a saving of 500*l*. a year.

Mr. J. H. Gladstone gives us the results of hyacinths grown under very varied influences of light, and solar heat, and chemical agency: that the yellow ray diminishes the growth of rootlets and the absorption of water; the red ray hinders the proper development of the plant; and total darkness causes a rapid and abundant growth of their rootlets, and prevents the formation of the green colouring-matter, but not that of the blue flower, nor of the other constituents of a healthy plant.

It has been observed that blue rays retard germination at first, although they probably accelerate the growth of the plant afterwards; the act of germination being attended with absorption of oxygen, but the process of development being, on the contrary, attended with the extrication of this gas.

COLORIFIC EFFECT OF THE SUN'S RAYS.

The power of the solar rays in developing fine colours is perhaps best seen on the sides of apples, peaches, &c., which, exposed to the midsummer sun, become highly coloured.

During the winter of 1851, a wall-flower afforded Mr. Adie of Liverpool a proof of the like effect: in the dark months there was a slow succession of one or two flowers of uniform pale-yellow hue; in March streaks of a darker yellow colour appeared on the flowers, and continued slowly to increase, till in April they were variegated brown and yellow of rich strong colours.

THE COLOURING OF FLOWERS.

M. Fritsch, the German botanist, has shown that the colouring of flowers is intimately connected with the alternations of the seasons. In Germany, he finds that invariably the number of flowers increases from December to July. White flowers are the most numerous during the whole of the year when plants are in blossom; then come yellow, orange, blue, violet, green, and lastly, the indigo flowers, which are the most uncommon.

The law of the increase of flowering is closely connected with the mean temperature; but from time to time anomalies are exhibited which change of temperature alone can explain: such is the rapid decrease of the number of flowering plants from the end of July to that of August. From January, when all the flowers are white, to the vernal equinox, the relative number of white flowers rapidly decreases; after which the proportion increases till the middle of May, and then insensibly diminishes till the season of frosts. Setting aside the very few yellow flowers which appear in February and March, the proportion of flowers of that colour increases from the beginning of April to the end of June; then it remains stationary till the middle of August, after which it increases again till the frosts. The proportional number of red flowers gradually diminishes from February to the end of April; increasing till the end of August, after which it decreases till October; it then rises again till November, when most of the cultivated flowers are of that colour. The green or greenish flowers diminish in number from March till the end of May, after which the proportion is about uniformly maintained till winter. Blue flowers increase till the middle of April; then decrease till the summer solstice, and next ascend to the number reached in April, after which they rapidly decrease, and totally cease on the arrival of frosts.

A table of these observations shows that each colour rises twice, and decreases twice. Whenever the white flowers increase, the yellow decrease, and *vice versâ*. The red and green always correspond, as do the blue and violet flowers. In conclusion, these laws apply to species, not to individuals.

THEORY OF RESPIRATION.

A man's chest contains nearly 200 cubic inches of air; but in ordinary breathing he takes in at one time and sends out again only about 20 cubic inches, the bulk of a full-sized orange; and he makes about 15 inspirations in a minute. He vitiates, therefore, in a minute about the sixth part of a cubic foot; but which, mixing, as it escapes, with many times as much of the air around, renders unfit for respiration three or four cubic feet. The removal of this impure air, and the supply in its stead of fresh air, is accomplished thus: the air which issues from the chest, being heated to near the temperature of the living body, viz. 98 degrees, and being thereby dilated, is lighter, bulk for bulk, than the surrounding air at the ordinary temperature; it therefore rises in the atmosphere, to be diffused there, as oil set free under water rises: in both cases a heavier fluid is, in fact, pushing up and taking the place of a lighter. This beautiful provision of nature, without trouble to the person, or even his being aware of it, is relieving him at every instant from the presence of a deadly though invisible poison, and replacing it with pure vital sustenance; and the process continues while he sleeps as while he wakes, and is as perfect for the unconscious babe, and even the brute creature, as for the wisest philosopher. In aid of this process come the greater motions in the atmosphere, called winds, which mingle the whole, and favour agencies which maintain the general purity.—*Dr. Neil Arnott.*

IMPORTANCE OF VENTILATION.

That the importance of the constant substitution of pure air taken from the general atmosphere for the contaminated air of enclosed localities has been so lately understood even by scientific men, and is still so little understood by the mass of the people, is explained by the fact, that a hundred years ago nobody on earth knew any thing of oxygen and nitrogen; or that the air we breathe, consisting of these, is as much a material substance as the water we drink or the food we eat,—indeed, consists of similar elements, only in different combination and form, —and that it can carry poison like these. Then, although men have long been aware that arsenic, prussic acid, and the other solid and liquid poisons, may all be rendered harmless,—nay, in certain cases may even be used as medicines when copiously diluted with pure water,—many have yet to learn that aërial poisons also can be rendered quite harmless by large admixture of pure air. In a locality where a deadly contagion prevails, the atmosphere at a short distance above it is no more contaminated by it than the deep stream of the Mississippi is contaminated by a child washing a foul rag near its bank: and mechanical art can now draw down pure air from the sky, and fill with it any dwelling, as certainly and as steadily as gas for burning is supplied to all persons who want it from the central gas-holder of a town.

The reasons of this imperfect ventilation are, that air under common circumstances is invisible; that scarcely two hundred years have passed since scientific men began to suspect that air was at all a ponderable space-occupying substance; and only in our own day—since it has been used as stuffing for air-pillows, and one kind with the name of coal-gas has been distributed and sold by measure from pipes, as water is. Hence people generally conceived of it as being truly a thing; that only about one hundred years ago did chemists learn that air or gas is not a distinct substance of a permanent nature, but is one of the three forms called solid, liquid, and aëriform, which certainly most, probably all, elementary substances may assume under different degrees of heat, compression, and combination: that the particular substance, for instance, to which the name of oxygen was given soon after its discovery, by Dr. Priestley in 1783, and which in its separate state, at the temperature of our earth, exists only as an air that might serve as a stuffing for cushions, yet constitutes eight-ninths by weight of all the water on our globe, about one-fourth of all the earth and stones, and a large proportion of the flesh and other parts of all animals and vegetables.—*Dr. Neil Arnott.*

ANALYSIS OF ATMOSPHERIC AIR.

Professor Liebig discovered, in 1850, a beautiful process for analysing atmospheric air. He found that one part of pyrogallic acid dissolved in five of water, and added to a solution of potassa, gives a liquid that will absorb oxygen air as rapidly as a pure potassa solution does carbonic acid. Availing himself of this fact, he has been enabled by a simple process to make analyses of atmospheric air equal to the best heretofore obtained by other processes.

PLANTS IN SLEEPING-ROOMS.

Plants are generally understood to be hurtful at night both in sleeping and sitting rooms, but beneficial by day, by two contrary operations, which are thus explained in *Kemp's Handbook of Gardening:*

"Plants convert oxygen and carbon, which they receive from the soil and air, into carbonic acid, which they exhale at night. This being a deadly and dangerous gas to human beings, plants and flowers are not considered healthy in a sitting or bed room during the night. In the day they give off oxygen, especially in the morning, which is reputed to render the morning air so fresh and exhilarating. They are very useful in absorbing from the air the carbon which is so injurious to animal life; and they purify stagnant water in the same way."

Dr. Sexton, in a communication to *Notes and Queries,* 2d Series, No. 29, thus illustrates this vexed question:

There are two distinct and apparently opposite processes going on in the plant. First, the decomposition of carbonic acid, the fixation of the carbon for the purpose of building up its own tissues, and the liberation of the oxygen. This constitutes vegetable nutrition. Second, the exhaling carbonic acid, the result of the union of the oxygen of the atmosphere with the carbon of the vegetable tissues. This is analogous to respiration.

The first of these processes is not only beneficial to animal life, but absolutely essential to its existence; for as the animal inhales oxygen and exhales carbonic acid in the process of respiration, if some agency did not work out the reverse change, the whole of the oxygen in the atmosphere would be used up in a certain length of time (800,000 years, according to Professor Dumas), and animal life consequently disappear. But, as it is, animals and plants are thus mutually dependent upon each other; and this is the case, not merely with regard to carbonic acid, but also some other compounds, such as ammonia, water, &c., which are formed in animals and decomposed in plants. So far, then, it is healthy to have plants in rooms.

But there is the second process—a kind of decay, or by some looked upon as a true respiration; and as this is precisely what occurs in animals, it must of course add to the carbonic acid of the atmosphere, and thus produce an effect prejudicial to animal life. If both these processes were carried on to the same extent, the one would as a matter of course counteract the other, and neither would produce either good or evil as to its effects upon the atmosphere. But as the former, under general circumstances, preponderates excessively over the latter, it is on the whole healthy to live among plants.

There are circumstances, however, in which the respiratory process is active, and the nutritive at a stand-still; where the influence of the vegetable upon the atmosphere will be injurious to animal life. One of these circumstances is the absence of sunshine, or daylight, as these stimuli are necessary to the carrying on of the process of nutrition in the plant. It is therefore injurious, more or less, to sleep in a room in which there are plants.

Notwithstanding this minute inquiry into the matter, in the *Quarterly Review*, No. 139 (Art. "The Flower Garden"), we find the fear of exhalations from flowers at night treated as a popular error.

FIRE AND PHLOGISTON.

The fiction that Fire is a substantial, though subtle, material element of nature, had been promulgated by Empedocles more than four centuries B.C.; handed down to the polypharmacists, it had played but a small figure in their doctrine; brought to Europe once more, the Alchemists had written not a little about it, but had made nothing of it as a theoretic centre: but now it was destined to quicken the whole mass of a growing chemistry, and to give that unity to all its parts, of which they stood more in need than ever. In fine, the ancient Greek, if not Egyptian, matter of fire, the empyrean element of the old quaternion, was at length recognised, set apart and consecrated by the hierophants of a young European science under the classical name and style of Phlogiston.

Here is a familiar illustration of this positive chemistry.

A lighted candle burns till it is done, giving out flame or matter of fire all the while:—for what reason, but because a candle is a compound of candle-matter and phlogiston, because that compound is decomposed when it burns, and because phlogiston is thereby set free and shows itself in the flame from the beginning to the end of the process? The pure aphlogisticated candle-matter is also liberated of course, little by little, as the taper burns from top to socket; that candle-matter turning out to be carbonic-acid gas and water, as discovered by later methods of research; so that, according to the phlogistic chemistry, tallow should have been tabulated as a compound of fire with water and fixed air: counting the ashes of the wick and oil, this was neither more nor less than the experiment of the Greek physiologists, after all:—phlogiston or fire, carbonic acid or air, moisture or water, and ashes or earth! Again, a stick of brimstone burns away with a blue flame and a suffocating vapour, and the residue of its combustion is sulphurous acid; in the language of the phlogistans, brimstone is a compound of two things, sulphurous acid and phlogiston; and when it is suffered to burn, it gives out its phlogiston, or flame of fire, and there remains its dephlogisticated sulphur, or sulphurous acid, in the separated state.

What a thing fire must have been to the primitive man the first time it flashed upon him! Say that he kept watch over his people; that at the chilliest hour of the night, just before sunrise, he noticed how a dry stick grew warm when rubbed against his club; that he rubbed them again more stoutly still, and it became hot: at it again, with the wonder of a child, and the strength of twenty men, he flung it down, for it scorched his hand; yet he could not choose but try again, and it smoked; again and again, quicker and quicker, longer and longer, he pursued the wild experiment until it burst into flame.—*North British Review,* No. 35.

THE FATE OF LAVOISIER.

Antoine Laurent Lavoisier, "the French lawgiver of chemistry," was born at Paris in 1743. He was educated at the College Mazarin, and having studied mathematics, astronomy, and botany, he took lessons in chemistry from old Rouelle, and to this science he dedicated himself, determined in his choice by the recent brilliant discoveries of Dr. Black. When only twenty-one years of age, he obtained the prize offered by the government for the best essay on lighting the streets of Paris; and to enable himself to judge of the intensity of the light afforded by lamps, he kept himself six weeks in total darkness, in order to intensify the sensibility of his eye. He now renounced Parisian society for the secluded pursuit of science; and put himself upon short commons of bread and milk, when he found that the want of air and exercise did him harm. In 1768, he was admitted an associate of the French Academy; and finding that he needed a good income for his studies, he obtained the appointment of a farmer-general of the public revenues. The chemists now said he had forsaken chemistry, and the farmers looked upon him as an interloper; but he eventually proved the best of farmers, and the greatest of the chemists of his day. He was next appointed to superintend the government saltpetre works, and in 1790 was made a member of the famous commission on weights and measures.

Meanwhile the revenue-farmer was working out a vast scheme of chemical discovery and doctrines, upon which he published forty memoirs within fifteen years. It is also recorded of him that he engaged in some of the most repulsive of chemical investigations from motives of humanity. Yet all his services and all his fine qualities could not save him from the revolutionary scaffold. Upon some paltry accusation of having authorised or winked at the putting of too much water on the Republic's tobacco, a number of the farmers-general were condemned to death; and Lavoisier was one of them. To avoid arrest, he secreted himself for some days in a cabinet of the Academy; whence he was dragged forth, like a skulking malefactor, insulted by a mock trial, and condemned to death. In answer to a request for a respite of some days, n order to finish certain experiments, which he stated were of mportance to the interests of mankind, he was coldly informed by the public accuser that the Republic had *no need of chemists*, and that the course of justice could not be delayed: he was then led to the guillotine, May 8, 1794.

The truly pathetic circumstance connected with this homicide was the fact, that the discoverer was just at the middle of his work, as he supposed. These are the last two sentences he ever wrote: "This is not the place to enter into any details concerning organised bodies; indeed, I have purposely avoided that subject, and that is the reason why I have refrained from speaking of the phenomena of respiration, sanguification, and animal heat. I shall return some day soon to these subjects." He never returned in the body; but his spirit is with us still, the nobler portion of the legacy he left to his disciples.

It is impossible within our limits to trace the succession of particulars in the progress of Lavoisier's career. The crowning moment was, perhaps, the following discovery: Oxygen had been discovered by Priestley and by himself: he had ascertained that it is the oxygen of the atmospheric air that becomes fixed (or absorbed and combined with) when brimstone is burnt, or a metal calcined; so that the calx of quicksilver was known to contain at least mercury and oxygen, whatever else t might contain. He therefore took a known weight of mercurial rust, and drove the oxygen out of it by heat (for simple heating decomposes that oxide), but did so in such an apparatus as enabled him to catch and retain that oxygen, as well as to preserve the liberated quicksilver. He next recalcined this same mercury, by means of the same oxygen as had been just expelled from the original calx employed; and he thereby obtained the same weight of the calx of mercury as had been introduced into the apparatus at the beginning of the experiment. This was an express illustration of the fact that the red rust of quicksilver is a compound of nothing ponderable but mercury and oxygen, instead of quicksilver being (as had been so long and loyally believed) a compound of its own calx with the positively light phlogiston. When it was made out that the sum of the weights of the mercury and the oxygen, obtainable by heat from any known weight of mercurial calx, is exactly equal to that weight, the experimental demonstration was complete. Yet it is a strange mistake to suppose that the history of true Chemistry reaches no further back than the period of this great reform. Ages were required to collect the world of phenomena of which Chemistry consisted before Lavoisier appeared. It required innumerable observations before men were able to attempt the explanation of that most striking though familiar phenomenon, the burning of a candle,—before they could seize the hidden clue which led to the conclusion that the rusting of iron in the air, the bleaching of vegetable colours, and the respiration of animals, were all dependent on the same cause as the combustion of inflammable substances. —*Abridged from the North British Review*, No. 35.

COLOURED FIRES.

Mr. F. A. Abel, Director of the Chemical Establishment of the War-Department, has found the most important materials for producing Coloured Fires to be—

The oxide and sulphide of copper, and the chlorate of copper and potassa; the nitrate of lead, the sulphide of arsenic (orpiment); the sulphide of mercury (*Ethiops mineral*), and the sub-chloride (calomel); zinc, antimony, and iron, as metals, in the state of filings, &c.; the carbonate, nitrate, and chloride of baryta; and the carbonate and nitrate of strontia. Chloride of potassa is largely employed to increase the vehemence of the combustion of many compositions containing colouring substances, whereby the brilliancy of the resulting tints is much heightened. The chlorate of baryta has lately been prepared on a very large scale for pyrotechnic compositions. In endeavouring to prepare a compound of the chlorate of copper with ammonia (similar to the so-called ammonio-nitrate of copper), as a material for a brilliant purple fire, Mr. Nicholson has obtained a beautifully crystalline compound, of so powerfully explosive a character that even its syrupy solution detonates sharply when struck with a hammer upon an anvil. The substance in question is more dangerous to manipulate with than fulminate of mercury, but it undergoes gradual decomposition on exposure to air, accompanied by a diminution of its explosive properties. This compound has led to the observation that the ammonio-nitrate of copper, when thoroughly dry, also possesses slight detonating properties.

In distilling the metal magnesium, which resembles zinc, if the current of hydrogen is too strong, a little metallic powder is carried out of the apparatus along with the hydrogen gas. If this powder is ignited, it burns with one of the most beautiful flames it is possible to imagine: this experiment would make a charming exhibition for a lecture-room.

ALDINI'S FIRE-PROOF DRESSES.

In Savoy, Corsica, Cornwall, and Scotland, is found a fibrous mineral, which when woven produces a fire-proof cloth; whence its name *Asbestos*, unconsumable. As the ancients were acquainted with the art of weaving this cloth, it was probably employed in the performance of some of their miracles—in enabling the victims of superstition to undergo without hazard the trial of ordeal by fire, when clad in asbestos garments and gloves made to imitate the human skin.

In our own times, by similar means to the above, the art of defending the hands and face, and, indeed, the whole body, from the action of intense fire has been applied to the nobler purposes of saving human life, and rescuing property from the flames. Sir Humphry Davy had long ago shown, in his safety-lamp for lighting mines, that the flame, being surrounded with wire-gauze, was prevented setting fire to the inflammable air without by the conducting and radiating power of the wire-gauze carrying off the heat of the flame, and depriving it of its power. The Chevalier Aldini of Milan has applied this material, with other badly conducting substances, as a protection against fire. The incombustible pieces of dress which he used for the body, arms, and legs were formed of stout cloth steeped in a strong solution of alum; while those for the head, feet, and hands were made of asbestos, or mountain-flax. The head-dress was a cap enveloping the head down to the neck, having perforations for the eyes, nose, and mouth. The stockings and cap were single; but the gloves were made of double asbestos cloth, to enable a fireman to handle burning or red-hot bodies. Over these was worn a metallic dress of five pieces, made of iron-wire gauze, the interval between its threads being the twentieth part of an inch. These pieces were a cap, with a mask large enough to leave a proper space between it and the asbestos cap; a cuirass with brassets; a piece of armour for the trunk and thighs; a pair of boots of double wire-gauze; and an oval shield of wire-gauze stretched over a slender iron frame.

To prove the safety of this apparatus to the firemen, Aldini showed that a finger first enveloped in asbestos, and then in a double case of wire-gauze, might be held a long time in a flame of a spirit-lamp or candle before the heat became inconvenient.

A fireman wearing a double asbestos glove, and the palm protected by a piece of asbestos cloth, seized with impunity a large piece of red-hot iron, and carried it deliberately 150 feet, inflamed straw with it, and brought it back to the furnace. On other occasions, the firemen handled blazing wood and burning substances, and walked during five minutes upon an iron grating placed over flaming fagots. In order to show how the head, eyes, and lungs were protected, the fireman put on the asbestos and wire-gauze cap and the cuirass, and then plunged his face into a fire of shavings; and in another trial at Paris, a fireman placed his head in the middle of flaming hay and wood, and resisted the fire ten minutes. In another trial, a fireman safely carried a child in a wicker-basket covered with metallic gauze (the child only wearing a cap of amianthine cloth) through a narrow place where flames from fagots and straw raged eight yards high.

Sir David Brewster observes in his *Natural Magic:* "It is a remarkable result of these experiments, that the firemen are able to breathe without difficulty in the middle of the flames. This effect is owing not only to the heat being intercepted by the wire-gauze as it passes to the lungs, in consequence of which the temperature becomes supportable, but also to the singular power which the body possesses of resisting great heats, and of breathing air of high temperatures."*

ASBESTOS.

Nearly two centuries since, the fire-proof property of Asbestos was publicly proved in England. Dr. Plot records that, at a meeting of the Royal Society in 1676, a merchant lately come from China exhibited a handkerchief made of Salamander's wool, or *Linum Asbesti*, which, to try whether it were genuine or no, was put into a strong charcoal fire, in which, not being injured, it was taken out, oiled, and put in again. The oil being burnt off, the handkerchief was taken out again, had only lost 2 dr. 5 gr. of its weight, but was more brittle than ordinary; but when it had grown cold, it nearly recovered its tenacity and weight. The merchant stated that he had received the handkerchief from a Tartar, who told him that among the Tartars this sort of cloth was sold at 80*l*. sterling the China ell, which is less than our ell; he added that the Chinese greatly used this cloth in burning the bodies (to preserve the ashes) of great persons; and that in Tartary Asbestos is "affirmed to be made of the root of a tree."

Sir Hans Sloane possessed in his museum a purse made of Asbestos, which he purchased of Dr. Franklin, who thus relates the circumstance in one of his letters: "Sir Hans Sloane heard of it, came to see me, and invited me to his house in Bloomsbury Square, showed me all his curiosities, and persuaded me to add that (the Asbestos purse) to the number, for which he paid me handsomely."

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* See "Protection from Intense Heat," in *Curiosities of Science*, First Series, pp. 191, 192.

CHEMISTRY OF A BLAST-FURNACE.

Had the results of combustion not been volatile, the combustive action would have been continually impeded. There can scarcely be conceived a more beautiful balance of power designed for a specific end than this; yet so familiar has the result become to us, so unnoticed by its very perfection, that an effort of chemical reasoning is required to enable us justly to appreciate this point in relation to the chemistry of carbon. The enormous quantity of ponderable, yet invisible, carbon removed in the draught of our larger fireplaces is, on its first announcement, startling; yet nothing admits of more satisfactory proof. Through an average-sized iron blast-furnace there rushes hourly no less a quantity of atmospheric air than six tons; carrying off 56-100ths, or more than half a ton, of carbon in the form of carbonic acid.—*Faraday.*

A striking instance of economic talent, says a writer in the *British Quarterly Review*, came to our knowledge in the district of Alston Moor. From the smelting earths of one "house," an arched tunnel conducts the smoke to an outlet at a distance from the works, in a waste spot, where no one can complain of it. The gathering matter, or "fume," resulting from the passage of the smoke is annually submitted to a process by which at that time it yielded enough of lead to pay for the construction of a chimney. A similar tunnel-chimney, three miles in length, has been erected at Allendale. Its fumes will yield thousands of pounds sterling per annum. Truly, here it may be said that smoke does not end in smoke.

PRODUCTS OF COMBUSTION IN GAS AND OIL LAMPS.

Mr. Faraday has shown that oil and gas each contains carbon and hydrogen, and each requires the addition of oxygen to bring about combustion. The *light* is one of the indications of the intensity of this union, and the substances which result from it are mainly two—*water*, by a combination of some of the oxygen with the hydrogen, and *carbonic acid*, by the combination of more of the oxygen with the carbon. The quantity of these two substances produced, owing to the enormous absorption of oxygen during the combustion, would by many persons be deemed quite extraordinary.

A pint of oil, when burned, produces a pint and a quarter of water, and a pound of gas, more than two pounds and a half of water; the increase of weight being due to the absorption of oxygen from the atmosphere, one part of hydrogen taking eight parts (by weight) of oxygen to form water. A London Argand gas-lamp, in a closed shop-window, will produce in four hours two pints and a half of water. A pound of oil also produces nearly three pounds of carbonic acid; and a pound of gas, two and a half pounds of carbonic acid. For every cubic foot of gas burned, rather more than a cubic foot of carbonic acid is produced.

As the water produced deadens the effect of the flame, and as the carbonic acid is very deleterious to the lungs, Mr. Faraday has contrived a very ingenious mode of carrying both off, without allowing them to mix with the air of the room. Air is admitted to feed the flame nearly in the usual way; but when the products of combustion have arrived at the top of the glass chimney, their progress is arrested by a covering of talc, and they are made to pass down between the chimney and another larger glass chimney concentric with it. The open space between the two chimneys communicates with a pipe, which is conducted into the open air. The carbonic acid, aqueous vapour, smoke, and other emanations from the flame, have no means of escape except through this tube, and they are thus wholly cut off from contact with the air of the room; while the light is brighter, the space around the lamp cooler, and the air of the room less vitiated, than when common open burners are used. This improvement was first devised for the lighting of the Athenæum Club, and has since been adopted in Buckingham Palace.

ANIMAL HEAT AND CHEMICAL PROCESSES.

To the builders of the automata of the last century, men and animals appeared as clockwork which was never wound up, and created the force which they exerted out of nothing. They did not know how to establish a connection between the nutriment consumed and the work generated. Since, however, we have learnt to discern in the steam-engine this origin of mechanical forces, we must inquire whether something similar does not hold good with regard to men. Indeed, the continuation of life is dependent on the consumption of nutritive materials: these are combustible substances, which, after digestion and being passed into the blood, actually undergo a slow combustion, and finally enter into almost the same combinations with the oxygen of the atmosphere that are produced in an open fire. As the quantity of heat generated by combustion is independent of the duration of the combustion and the steps in which it occurs, we can calculate from the mass of the consumed material how much heat, or its equivalent work, is thereby generated in an animal body. Unfortunately the difficulty of the experiments is still very great; but, within those limits of accuracy which have been as yet attainable, the experiments show that the heat generated in the animal body corresponds to the amount which would be generated by the chemical processes. The animal body, therefore, does not differ from the steam-engine as regards the manner in which it obtains heat and force,* but does differ from it in the manner in which the force gained is to be made use of. The body is, besides, more limited than the machine in the choice of its fuel: the latter could be heated with sugar, with starch, flour, and butter, just as well as with coal or wood; the animal body must dissolve its materials artifically, and distribute them through its system. It must further perpetually renew the used-up materials of its organs; and as it cannot itself create the matter necessary for this, the matter must come from without. Liebig was the first to point out these various uses of the consumed nutriment. As material for the perpetual renewal of the body, it seems that certain definite albuminous substances which appear in plants, and form the chief mass of the animal body, can alone be used. They form but a portion of the mass of nutriment taken daily; the remainder, sugar, starch, fat, are really only materials for warming, and are perhaps not to be superseded by coal, simply because the latter does not permit itself to be dissolved.

If, then, the processes in the animal body are not in this respect to be distinguished from inorganic processes, the question arises, Whence comes the nutriment which constitutes the source of the body's force? The answer is, from the vegetable kingdom; for only the material of plants, or the flesh of plant-eating animals, can be made use of for food. The animals which live on plants occupy a mean position between carnivorous animals, in which we reckon man, and vegetables, which the former could not make use of immediately as nutriment. In hay and grass the same nutritive substances are present as in meal and flour, but in less quantity. As, however, the digestive organs of man are not in a condition to extract the small quantity of the useful from the great excess of the insoluble, we submit, in the first place, these substances to the powerful digestion of the ox, permit the nourishment to store itself in the animal's body, in order in the end to gain it for ourselves in a more agreeable and useful form. In answer to our question, therefore, we are referred to the vegetable world. Now when what plants take in and what they give out are made the subjects of investigation, we find that the principal part of the former consists in the products of combustion which are generated by the animal. They take the consumed carbon, given off in respiration as carbonic acid, from the air, the consumed hydrogen as water, the nitrogen, in its simplest and closest combination, as ammonia ; and from these materials, with the assistance of small ingredients which they take from the soil, they generate anew the compound combustible substances, albumen, sugar, oil, on which the animal subsists.

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* See "The Steam-engine and the Human Body compared," in *Things not generally Known*, First Series, page 68

Here, therefore, is a circuit which appears to be a perpetual store of force. Plants prepare fuel and nutriment, animals consume these, burn them slowly in their lungs ; and from the products of combustion the plants again derive their nutriment. The latter is an eternal source of chemical, the former of mechanical, forces. Would not the combination of both organic kingdoms produce the perpetual motion ? We must not conclude hastily. Further inquiry shows that plants are capable of producing combustible substances only when they are under the influence of the sun. A portion of the sun's rays exhibits a remarkable relation to chemical forces,—it can produce and destroy chemical combinations ; and these rays, which for the most part are blue or violet, are called, therefore, chemical rays. We make use of their action in the production of photographs. Here compounds of silver are decomposed at the place where the sun's rays strike them. The same rays overpower in the green leaves of plants the strong chemical affinity of the carbon of the carbonic acid for oxygen, give back the latter free to the atmosphere, and accumulate the other, in combination with other bodies, as woody fibre, starch, oil, or resin. These chemically active rays of the sun disappear completely as soon as they encounter the green portions of the plants ; and hence it is that in Daguerréotype images the green leaves of plants appear uniformly black. Inasmuch as the light coming from them does not contain the chemical rays, it is unable to act upon the silver compounds.

Hence a certain portion of force disappears from the sunlight, while combustible substances are generated and accumulated in plants ; and we can assume it as very probable that the former is the cause of the latter. It must, indeed, be remarked, that we are in possession of no experiments from which we might determine whether the *vis viva* of the sun's rays which have disappeared corresponds to the chemical forces accumulated during the same time ; and as long as these experiments are wanting, we cannot regard the stated relation as a certainty. If this view should prove correct, we derive from it the flattering result, that all force, by means of which our bodies live and move, finds its source in the purest sunlight ; and hence we are all, in point of nobility, not behind the race of the great monarch of China, who heretofore alone called himself son of the sun.

But it must also be conceded that our lower fellow-beings, the frog and leech, share the same æthereal origin, as also the whole vegetable world; and even the fuel which comes to us from the ages past, as well as the youngest offspring of the forest, with which we heat our stoves and set our machines in motion.—*Prof. Helmholtz on the Interaction of Natural Forces.*

SCIENCE AND ITS APPLIERS.

In many fields of human exertion, the tasks of purely scientific research and of the subsequent applications of art have lain very much with different parties. It was not, for example, the chemist who first showed a jet of coal-gas burning in his laboratory who also first conceived and accomplished the noble feat of lighting up with gas a whole city, so as almost to make night there appear the day. It was not the persons who, ages ago, observed the expansive force of steam, and its sudden collapse again into water when cooled, who thought of turning steam-force to profitable use; for it was left to James Watt, almost in our own day, to devise the present steam-engine, which has quickly spread a newer and higher civilisation over the earth. And then for many a day was the fact widely known that a shock of electricity travelled along a wire with the speed of lightning before Wheatstone and others, who still live among us, had constructed the electric telegraph, which, with the speed of lightning, can deliver at any distance, and can either write down or print the words of a message committed to it.

Real philosophers may, however, be considered to have done much by their own inventions for the useful arts. Thus the chemical or mechanical manufacturer has merely applied what the philosopher has made known; he has merely worked up the materials furnished to him. The chlorine, or oxymuriatic gas, of Scheele was scarcely known before it was applied by Berthollet to bleaching; scarcely was muriatic gas discovered by Priestley, when Guyton de Morveau used it for destroying contagion. Platinum owes its existence as a useful metal entirely to the labours of an illustrious chemical philosopher. Look at the beautiful yellow afforded by the metal chrome; consider the medical effects of iodine! We have no history of the manner in which iodine was rendered malleable; but we know that platinum could only have been worked by a person of the most refined chemical resources. But such results are not uniform. "The production of chloroform is amongst the most subtle experimental results of modern chemistry. The blessed effects of its proper exhibition in the diminution of the sum of human agony are indescribable. But that divine-like application was not present to the mind of the scientific chemist who discovered the anæsthetic product any more than was the gaslit town to the mind of Priestley, or the condensing engine to that of Black."—*Prof. Owen.*

OPPOSITION TO SCIENTIFIC IMPROVEMENTS.

Almost all the great modern improvements in the arts of life have been received with ridicule at first, and then with more active resistance—as in the cases, for instance, of agricultural implements worked by steam, of steam machinery for spinning and weaving, of gas-lighting, railways, steam navigation, the penny postage, and so forth. By such opposition as this the full introduction of Watt's steam-engine was retarded for many years, and the inventor had to defend his patent-rights by repeated appeals to courts of justice. But sometimes even enlightened and upright men have been slower than might have been expected to acknowledge the merit in new inventions, partly from caution, taught them by seeing the mass of crudities and absurdities constantly pressed on public attention as improvements by ignorant or foolish projectors, and partly because sufficient evidence of the worth of the new proposal was not yet before them. For instance, such distinguished men as Davy, Wollaston, and Watt at first gave an opinion that coal-gas could never be safely applied to the purpose of street-lighting. Others said that steam-ships would never be able safely to navigate the great ocean. When Dr. Desaguliers and Dr. Hales, about a century ago, before oxygen was known, or the nature of gases generally was understood, still judged aright of the importance of pure air to health and life, and proposed to ventilate houses or ships by mechanical means of certain or unfailing action, instead of by the agency of the inconstant wind entering windows, ports, or wind-sails, they were regarded by some honest persons in authority as erring visionaries. A curious fact belonging to this class of occurrences, and recorded by the writers of the time, was that, after Dr. Harvey published his great discovery of the Circulation of the Blood, no medical man who had then reached the age of forty ever avowed his belief that Harvey was right.—*Dr. N. Arnott.*

ALL THE OXYGEN IN THE WORLD.

Let us for an instant contemplate (says Faraday, in his *Lectures on the Non-metallic Elements*) the enormous amount of Oxygen employed in the function alone of respiration, which may be considered in the light of a slow combustion. For the respiration of human beings, it has been calculated that no less than one thousand millions of pounds of oxygen are required daily; and double that quantity for the respiration of animals; whilst the processes of combination and fermentation require one thousand millions of pounds more. But at least double the whole preceding quantity, that is to say, twice four thousand millions of pounds of oxygen, are calculated to be necessary altogether, including the amount for the never-ceasing functions of decay. In tons it corresponds with no less than

7,142,857 in a day;
2,609,285,714 in a year;
260,928,571,400 in a century;
15,655,744,284,000 in 6000 years;
Whole quantity, 1,178,158,000,000,000.

Such being the daily requisition of oxygen in the economy of nature, how great must be the quantity existing in the world! Why, between one-half and two-thirds of the crust of this globe and its inhabitants are composed of oxygen.

CONDENSATION BY SURFACES.

Every porous body—rocks, stones, the clods of the fields, &c.—imbibes air, and therefore oxygen. The smallest solid molecule is thus surrounded by its own atmosphere of condensed oxygen; and if in the vicinity other bodies exist which have an affinity for oxygen, a combination is effected. When, for instance, carbon and hydrogen are thus present, they are converted into nourishment for vegetables—into carbonic acid and water. The development of heat, when air or watery vapour is absorbed, or when the earth is moistened by rain, is acknowledged to be the consequence of this condensation by the action of surfaces.—*Liebig.*

WHAT IS OZONE?

The allotropic, or "other" condition of oxygen, replies Professor Brande. By means of a delicate test, first proposed by M. Schönbein, the discoverer of ozone, we can readily detect its presence even when it exists in very small quantities. This test is paper imbued with a solution of iodide of potassium and starch. If a slip of this paper be taken near the sea-shore, moistened with water, and exposed for a few seconds to the *air, when a breeze is blowing from the land,* no evident change ensues. *If, however, the breeze is blowing in the opposite direction,* from the sea *towards* the land, then the paper, originally white, assumes a tinge of blue; thus proving the operation of a certain atmospheric influence or agent, which we shall find hereafter to be ozone. It may be generated from phosphorus and water, and by other methods. One must not, however, be passed over, inasmuch as a great portion of the ozonomised oxygen existing in nature is, in all probability, referable to it—namely, *electricity.* All electrical experimenters must have noticed the *odour* from an electric machine in action. Now the air in the bottle, or from the phosphorus and water, or ozone, is so similar in smell as to create a possibility that the electrical odour is immediately referable to ozone; and the test-paper of Schönbein, if exposed to electric sparks, or electric pencils emanating from a point, becomes in like manner tinged blue. The connection thus established between electricity and ozone points to a fertile source of this most remarkable agent in nature. We now see the theory of the old process of bleaching by exposure to atmospheric influences,—why the operation was more successful at certain times than at others; why certain localities were especially adapted for it; and why the operation proceeded with increased rapidity after the occurrence of thunder-storms.

HYDROGEN.—THE LIGHTEST MATTER.

Even now, says Professor Brande, we are justified in hypothetically regarding hydrogen as a gaseous *metallic body;* water as a *metallic oxide.* Hydrogen gas is the lightest ponderable matter known. Dobreiner considers it to be a metal dissolved in caloric.

In 1849, M. Van Alsten, of Rotterdam, made the experiment on his own person of testing to what degree a man might, without danger, inhale hydrogen gas; when, in spite of all the exertions of his physicians, he died in a few hours.

MERCURIAL ATMOSPHERE.

It had long been admitted that in the upper part of the thermometer and barometer an atmosphere of mercury existed having a very small degree of tension, when Mr. Faraday showed, by the following simple experiment, that a mercurial atmosphere may exist without removing the air. A small portion of mercury was put through a funnel in a clean, dry bottle capable of holding six ounces, and formed a stratum at the bottom not one-eight of an inch in thickness; particular care being taken that none of the mercury should adhere to the upper part of the inside of the bottle. A small piece of gold-leaf was then attached to the under part of the stopper of the bottle, so that, when the stopper was put in its place, the leaf-gold was enclosed in the bottle. It was then set aside in a dark and cool place, and left for six or eight weeks; at the end of which time the leaf-gold was found whitened by the mercury, though every part of the bottle and the mercury remained apparently just as before. This experiment was repeated several times, showing the mercury to be always surrounded by an atmosphere of the same substance.

WATER ANCIENTLY AN ELEMENT.

Water was considered to be an element by the ancients, an opinion which has been thought to be unreasonable and ridiculous by some; but (says Faraday), for me, I confess my inability to see how the ancients, with the amount of evidence at their disposal, could have arrived at any other conclusion. Viewed in its relation to the universe,—to its great natural manifestations,—to the large range of substances into which it enters,—to the manifold purposes it subserves,—and, more than all, viewed in relation to its intimate connection with living forms,—water does seem to present to our minds the leading qualities of an element; and it is only by the aid of chemical analysis that we prove the idea to be incorrect. Consider how widely water is distributed throughout nature,—how numerous are its functions,—how tremendous its operations, —and yet how mild, how bland, how seemingly powerless this wonderful liquid is! Let us view it in relation to the structure of living beings, and reflect how intimately it seems connected with vitality. Not only does it bathe the most delicate tissues and organs with impunity, but it enters largely into the composition of all organised forms. No structure of corporeal vitality is without it as an essential element. Water constitutes at least nine-tenths by weight of our own bodies, entering into the very bones; yet this is but a trifling fraction of the amount of water entering into the structure of certain lower animals. Look at those delicate sea beings the medusæ, and reflect upon the vast amount of water which their structures contain! Pellucid almost as the ocean in which they dwell, these creatures float about in the full vigour of life; yet one may safely say that the medusæ consist of no less than nine hundred and ninety-nine parts water! Water in this great amount pervades their whole economy. Without much violence to language, we might call them living forms of water! Yet these same medusæ, taken from the ocean and scattered on the beach, exposed to the influence of sun and air, their aqueous portion gone, what are the medusæ then? Shadows almost—a substance barely—the merest shred of filament and membrane!

THE COMPOSITION OF WATER.

The celebrated experiment by which it was proved that Water is composed of oxygen and hydrogen deprived of part of their latent heat, was suggested by the following circumstances. In the year 1776, Volta fired inflammable air by a simple electric spark. In 1776-7, Macqueer burned mixtures of inflammable air and oxygen in glass vessels, and observed that the part of the saucer which the flame licked was moistened with small drops of a liquor as clear as water, and which appeared to him to be pure water. Macqueer, however, drew no conclusion from his experiments; and it was not till some time before the 18th of April 1781 that a similar experiment was made by Priestley and Waltire, a lecturer on chemistry at Birmingham, who fired a mixture of common and inflammable airs, and of inflammable air and oxygen, and *observed a deposit of water on the side of the vessel.* Priestley further says: "In order to judge more accurately of the quantity of water so deposited, and to compare it with the weight of the air decomposed, I carefully weighed a piece of filtering-paper, and then having wiped with it all the inside of the glass vessel in which the air had been decomposed, weighed it again, and *I always found, as nearly as I could judge, the weight of the decomposed air in the moisture acquired by the paper.*"

We have not space to enter into the controversy respecting the Composition of Water, *i.e.* whether it was discovered by Watt or Cavendish. According to the statement of the Rev. W. Vernon Harcourt, Cavendish's final experiment—so contrived as to enable him to consume a large quantity of the gases, sufficient to prove that the fluid condensed was pure water—was made on one of the latter *Sundays* of July 1781: thus completely establishing the general fact of the composition of water.

The following details of the great analysis, made a few years later, are very interesting:

> Fourcroy, Vauquelin, and Seguin commenced, on the 13th of May 1790, an experiment on a very large scale to prove the composition of water, and finished their labours on the 22d of the same month. The hydrogen was produced from zinc, which, after being melted, had been rubbed to a powder in a hot mortar, and strong oil of vitriol diluted with seven times the quantity of water. The gas was then passed through caustic potash to clear it from any impurities. The oxygen was obtained by heating chlorate of potassa, and was purified in a similar manner.
>
> The hydrogen used in the experiment was 25,963·568 cubic inches, weighing 1039·358 grains; and the oxygen 12,570·942 cubic inches, weighing 6209·869 grains. The combustion of the gases was continued for 185 hours without intermission, and the apparatus was not quitted for a moment, the experimenters resting themselves in the laboratory alternately when fatigued. The result was, that 7244 grains of water were procured, showing a loss of only five grains, or $\frac{1}{1449}$ of the whole.

In a glass jar put a mixture of two parts by measure of hydrogen with one of oxygen; the two gases will remain calm, tranquil, quiescent; transparent and colourless as the atmosphere itself; they give no indication of their power. But a most extraordinary force is there, which force, if we reduce to a certain standard of comparison,—and such standard is not wanting,—will be found to equal the power of many thunderstorms. To exemplify this, fill a bag with the mixed gases, and then blow some soap-bubbles, to which apply a lighted taper, when the result will be a violent explosion. In this result we have the evidence of tremendous power. But the result of the explosion is water—*nothing but water.* To me (says Faraday), the whole range of natural phenomena does not present a more wonderful result than this. To think that these two violent elements, holding in their admixed parts the power of whole thunder-storms, should wait indefinitely until some cause of union be applied, and then furiously rush into combination, and form the bland unirritating liquid water, is to me, I confess, a phenomenon which continually awakens new feelings of wonder as often as I view it. Or, if we place in a globe oxygen and hydrogen gases in the exact proportions in which they combine to form water, they remain without change of state, but appear to mix intimately. The moment, however, that an incandescent body, or the spark from an electric machine, is brought into contact with the mixed gases, they ignite, explode violently, and combine to form water. When hydrogen gas is allowed to flow on the surface of spongy platinum, the pores of which contain condensed oxygen, water is formed by the combination of the two gases, heat is developed, and the platinum becoming red-hot, the jet soon takes fire.

HARD AND SOFT WATERS.

Dr. Lander Lindsay uses the term *hard waters* to indicate waters containing an easily appreciable amount of neutral salts, especially of the carbonates, sulphates, and chlorides of lime and magnesia. Under this head a large proportion of spring waters is to be classed. The term is employed in contradistinction to that of *pure* or *soft* waters, which either contain no saline ingredients, or a very small proportion: such are rain, snow, and many river waters. There is frequently great difference of opinion between professional and non-professional persons as to what is, or constitutes, *hard* or *soft* water. A water was reported upon by the analyst, an English chemist of repute, as "*very soft;*" while the user of the water, a lady of great intelligence and experience, described it to Dr. Lindsay as decidedly *hard.*

Professor Christison considers a water *soft* which contains less than $\frac{1}{5000}$ part of its weight of saline ingredients; *hard* if it contains more than $\frac{1}{4000}$; *mineral* if more than $\frac{1}{2000}$. *Soft* water has the property of forming a lather with soap, and it is suitable for washing purposes, neither of which properties does *hard* water possess.

WATER TEST.

The chemical property possessed by soap, of readily dissolving in alcohol, renders the solution a valuable qualitative test for discriminating approximately the presence or absence of metallic bases in water. If an alcoholic solution of soap be poured into distilled water, no perceptible change ensues; but if the same solution be poured into any ordinary variety of natural terrestrial water, a certain amount of turbidity results, according to the amount present of earthy or metallic bases: hence, by this test, the comparative softness or hardness of different waters may be rendered evident.

FILTERING WATER.

In a lecture recently delivered at the Royal Institution, Dr. Lankester insisted upon the necessity for filtering all water used in drinking or cooking, from whatever source; and proved to his audience, by chemical analysis, that unfiltered water, however clear and bright, may contain the most deleterious if not the most deadly constituents. The lecturer the more impressively substantiated the fact by the analysis of the water from a notoriously favourite pump. The water was quite cool, fresh, and tasteless to the palate, owing to a peculiar combination of nitric acid; but, upon chemical tests being applied, it yielded a large amount of deleterious matter.

NITROGEN.

Nitrogen is a permanently elastic gas, a little lighter than atmospheric air, but fourteen times heavier than hydrogen; it has neither smell, taste, nor colour; it is not absorbable by water, and neither supports combustion nor respiration. All burning bodies are immediately extinguished when plunged into this gas, and so is animal life: it appears to kill, not by any direct chemical action upon the blood, as is the case with almost all noxious gases, but simply by the exclusion of oxygen, preventing the throwing off of carbonic acid; so that animals are rather stifled by nitrogen, as they are by suffocation or drowning, than absolutely poisoned. Now from all these illustrations, it will be obvious that the characters of nitrogen are preëminently of a negative description: it appears as a very *indifferent* body. Not so, however, when in chemical combination; for nearly all its compounds are preëminently active and energetic: powerful acids, acrid alkalies, intense poisons, violent detonators, are amongst them. Nitric acid, ammonia, and cyanogen belong to this class; they are binary compounds of nitrogen: all the most dangerous fulminators contain it as one of their essential elements; gunpowder cannot be made without it; in short, whether we look at nitrogen under those simpler forms of combination, which, to a certain extent, may be commanded by art, or under those more complicated relations which can only be called into existence by vital functions, we find its chemical history full of instructive and important details.—*Brande's Lectures.*

SERVICES OF NITROGEN IN THE ATMOSPHERE.

These are very important. Nitrogen, as the chief constituent in weight and bulk of the atmosphere, diminishes the rapidity of combustion and oxidation at the earth's surface; whilst as a great gaseous envelope, which the ocean and tributary waters cannot dissolve, and which neither acts injuriously on rocks, plants, or animals, nor is altered in quality by them, it forms a permanent medium for the production of winds, and a moderator and equaliser of the sidereal light; heat, and other agencies determining climatic differences, such as no other gas, simple or compound, known to us could be. —*Dr. G. Wilson.*

NITROGEN AND GUN-COTTON.

"Nitrogen," says Gmelin, "has probably the greatest affinity of all ponderable bodies for heat, with which it constantly tends to form a gas. Consequently, many of its compounds are decomposed by slight causes, and with extreme suddenness, the nitrogen being disengaged in the gaseous form, and often producing the most violent explosions." Thus it confers explosiveness on its compounds, as in gunpowder; the various bodies of which Gun-cotton is the type; percussion-cap powder, and other fulminates; the so-called ammoniuret of gold; and the chloride and iodide of nitrogen.

In a greatly lessened degree, this chemical fragility and instability are conferred by nitrogen upon the compounds which it forms with living organisms. The immensely greater and more numerous chemical changes which characterise animals than plants are essentially connected with the greater abundance of nitrogen in the former. The difference between the slightly alterable, slowly combustible vegetable cotton, a compound of carbon, hydrogen, and oxygen, and the spontaneously decomposable explosive Gun-cotton, which differs from it in quality of ingredients by the addition of nitrogen, is typical of the distinction between the enduring non-nitrogenous vegetable compounds, and the spontaneously changeable nitrogenous animal compounds; although, in this particular case, the increase of oxygen in the Gun-cotton exaggerates the instability to the point of explosion.

The simplest process of making Gun-cotton consists in dipping the fibre (which must be perfectly clean) into strong nitric acid, allowing the acid to saturate it thoroughly, then finally removing the cotton-fibre, washing it until every trace of acid is separated, and drying it at a temperature under 100°. Practically, however, it is found desirable to mix a little sulphuric acid with the nitric acid, for the purpose of strengthening the latter, which it accomplishes by its affinity for water.

Gun-cotton, although still resembling ordinary cotton to the naked eye, feels different, and presents a different aspect when examined microscopically.

The composition of Gun-cotton has not been accurately determined, nor are chemists agreed as to the rational formula by which it may be represented. We must therefore rest satisfied with regarding it as a combination of nitric acid, or of nitrous acid with lignine, or modified lignine, in which the latter performs the part of a base. (*Brande's Lectures.*)

In an experiment performed in Schönbein's laboratory at Basle, a certain weight of gunpowder, when fired, filled the apartment with smoke; whilst an equal weight of Gun-cotton exploded without producing any smoke, leaving only a few atoms of carbonaceous matter behind. Balls and shells were experimentally projected by this prepared Cotton, which was stated to have nearly double the projectile force of gunpowder; in proof of which Schönbein experimented upon the wall of an old castle near Basle. It had been calculated that from three to four *pounds* of gunpowder would be requisite to destroy this wall, and a hole to contain that quantity was prepared. In this aperture were put four *ounces* of the prepared cotton, which, when fired, blew the massive wall to pieces.

Again, the sixteenth of an ounce of the Cotton, placed in a gun, carried a ball through two planks at the distance of 28 paces; and, with the same charge and distance, drove a bullet into a wall 3¾ inches. A dram of the cotton also sent a ball, ¾oz. weight, to a distance of 200 paces, where it penetrated a deal plank to the depth of two inches. A portion of this cotton, when thrown into water, and afterwards dried, did not lose its inflammable property. Such were the earliest experiments made by Schönbein, the inventor, in Switzerland.

Gun-cotton was used for the first time in actual warfare at the siege of Moultan in the East Indies; when the brilliance and breadth of the flash of the guns fired by this new adaptation of science to the devastation of war are described to have been of terrific intensity.

But the new compound has other uses. Gun-cotton is soluble in ether, and a compound is formed, to which the name of *collodion* has been given. This substance has been found of the greatest use in many of the arts, especially photography. On being exposed to the air, the ether evaporates, leaving behind a thin transparent film, which is applied to wounded surfaces instead of goldbeaters' skin. It may also be made into delicate bags, into which hydrogen may be introduced for balloons. In photography, the collodion is mixed with the iodides to be acted on by light; and being spread on glass, pictures, from which any number of impressions may be taken, are produced.

Although the British Board of Ordnance have decided against the adoption of this explosive compound in the military and naval services, its advantages have been differently appreciated on the Continent, the Austrian government having presented Professor Schönbein with the sum of 2500*l*. as a reward for his invention.

A new kind of Gun-cotton has been prepared in the United States, by treating newly-prepared Gun-cotton with a saturated solution of chlorate of potash. A pistol loaded with one grain of this cotton has sent a ball through a yellow pine door one inch thick, at the distance of 20 feet.

Many circumstances conspire to prevent the application of Gun-cotton to the purposes of gunnery. Its velocity of combustion is too great for all fire-arms, save those of the strongest make and smallest bore. Its strength is subject to variation, not only from the operation of atmospheric causes, such as the absorption of moisture, but from spontaneous decomposition; the latter agency reducing Gun-cotton, after a certain time, to the original condition, or ordinary combustibility, of native cotton. The physical conditions of a fibrous body, moreover, are very much opposed to the employment in fire-arms of Gun-cotton. Other objections are those of ignition from percussion, or even spontaneously, and the acid fumes (although no smoke) evolved by Gun-cotton undergoing combustion. Its employment as a blasting agent in mines promised greater success; its freedom from smoke being a great advantage to the miner. Unfortunately, however, the use of Gun-cotton has been discontinued even for this purpose, chiefly on account of the danger attending its manufacture, and its liability to explode from the operation of very slight causes.

PRUSSIC ACID.

In the bicarburet of nitrogen, termed cyanogen, we have an extraordinary example of the indirect manner in which certain compositions are effected, no less than of the wonderful change of properties which results. Carbonic acid, although poisonous under certain circumstances, is concerned in the ever-occurring function of respiration, bathing unharmed the air-cells of the lungs, remaining in contact with the most delicate tissues, yet producing no evil result: nitrogen, too, is endowed with a similar negative quality, this element constituting no less than four-fifths of our atmosphere, which we breathe, almost unconsciously, without intermission from our birth to our death. Yet such is the strange effect of combination, that nitrogen, when united with carbon in the ratio of fourteen parts by weight to twelve, gives rise to a peculiar gaseous substance termed cyanogen, which, if breathed only in small quantities, proves fatal at once, and which, by union with hydrogen, constitutes that terrible—most terrible perhaps of all poisons, Prussic acid. The odour of cyanogen is that of peach-blossoms, and when burned it evolves a peculiar rose-coloured flame, which is very distinctive of this gas.

HOW SIR HUMPHRY DAVY BREATHED NITROUS OXIDE.

Davy, for this investigation, devised the very beautiful method of procuring the nitrous air, viz. the decomposition by heat of the crystals of nitrate of ammonia, which are thereby dissolved into watery vapour and the desiderated gas. Under the famous name of nitrous oxide, he minutely examined and recorded its properties for the first time. In his *Researches* he tells us:

> Having previously closed my nostrils and exhausted my lungs, I breathed four quarts of nitrous oxide from and into a silk bag. The first feelings were similar to giddiness; but in less than half a minute, the respiration being continued, they diminished gradually, and were succeeded by a sensation analogous to gentle pressure on all the muscles, attended by a highly pleasurable thrilling, particularly in the chest and the extremities. The objects around me became dazzling, and my hearing more acute. Towards the last inspiration the thrilling increased, and at last an irresistible propensity was indulged in. I recollect but indistinctly what followed: I know that my motions were various and violent. These effects very soon ceased after respiration, in ten minutes I had recovered my natural state of mind. Almost every one who has breathed this gas has observed the same thing. On some few, indeed, it has no effect whatever, and on others the effects are always painful. The experiment cannot be made with impunity by those who are liable to determination of blood to the head.

Davy was at first sanguine of the useful application of nitrous oxide to medicine. It might be the Potable Gold of Geber, the vivifying quintessence of the Elements of Raymond Lully, the Water of Life of Basil Valentine, the Elixir of Paracelsus, at least some purified and attempered supporter of vitality, for its composition was almost identical in its ingredients with that of the atmosphere. But Davy soon discovered his mistake, recorded its inutility, and pointed out the fallacies attendant on the trial of so strange and novel a medicinal agent.

SULPHURING WINE-CASKS.

The rationale of this familiar process is as follows: when the sulphur is burned in the wine-casks, the oxygen taken up by the wine from the air during the filling of the casks is seized by the sulphurous acid, whence the formation of vinegar s thus prevented, and the wine is insured from acidity.

STORES OF CARBON IN COAL-FIELDS.

Calculation shows that the present amount of atmospheric carbonic acid is sufficient for keeping up the large amount of carbon which vegetables require. But the question has been mooted, whether an atmosphere containing no more carbonic acid than at present could have been reasonably assumed to have furnished that enormous amount of Carbon which is stored away in our Coal-fields. Probably, it is assumed, the atmosphere in that early period of the world, when coal-fields were deposited, contained more carbonic acid than it does at present; but for the greater number of vegetable species an atmosphere charged with any considerable amount of carbonic acid over and above that supplied to us is fatal. As regards the fern tribe, however, they have been proved by experiment to be capable of living and thriving in an atmosphere containing an amount of carbonic acid fatal to other species. Now the fact is well known that coal-fields are chiefly made up of the remains of gigantic ferns; and hence we recognise the exercise of a wise forethought in so adapting the organism of these vegetables that they could live and flourish in an atmosphere of carbonic acid which would be fatal to most other vegetables and the higher order of animals.—*Faraday.*

CAOUTCHOUC AND CAOUTCHOUCINE.

The following simple experiments pleasingly illustrate the properties of India rubber, or Caoutchouc, and the spirit distilled from it, named Caoutchoucine.

Put a little ether into a bottle of Caoutchouc, close it tightly, soak it in hot water, and it will become inflated to a considerable size. These globes may be made so thin as to be transparent. A piece of caoutchouc the size of a walnut has thus been extended to a ball fifteen inches in diameter; and a few years since a Caoutchouc balloon thus made escaped from Philadelphia, and was found 130 miles from that city.

Dissolve a small piece of Caoutchouc in a little Caoutchoucine, and put a drop or two of the solution upon a looking-glass or window-pane; touch it lightly with a dry piece of India rubber, quickly draw out a fine thread, which attach to a card, and wind off as silk.

Put Caoutchoucine into a phial, little more than sufficient to cover the bottom, and the remainder of the phial will be filled with a heavy vapour; pour this off the spirit into another phial; apply to it a piece of lighted paper, and the vapour will burn with a brilliant flame.

IDENTITY OF THE DIAMOND AND CARBON.

That Diamond is simple Carbon (not charcoal) is shown by the following experiment. M. Morveau exposed to intense heat a diamond shut up in a small cavity in a piece of tough iron. When he opened the cavity, the diamond was entirely gone, and the iron around it was converted into steel. This shows that it is pure carbon, which combines with iron to form steel; and not charcoal, which is generally an oxide of carbon. In 1815, Mr. Children converted iron into steel by union with diamond, under the sole action of a large voltaic battery.

The combustion of the Diamond is effected by holding the gem by a little platinum clamp and igniting it to whiteness in the oxyhydrogen flame; and then plunging it, while incandescent, into a jar of oxygen. Eventually the resulting gas is proved, by means of the lime-water test, to be carbonic acid.

Diamonds which have been exposed under peculiar conditions to an intense heat may be seen to have lost their crystalline aspect—to have *opened out*, forming a cauliflower-like excrescence, and to have assumed the aspect of coke. Such specimens are most curious, as furnishing us with a striking instance of allotropism—that mysterious existence of identical matter in two states.

The only chemical difference perceptible between Diamond and the purest Charcoal is the hydrogen contained in the latter, which is, in some cases, less than $\frac{1}{50000}$ part of the weight of the substance. Mr. Smithson Tennant and Dr. Ure, however, considered Diamond to differ from the usual form of Charcoal only by its crystallised form.

Sir Humphry Davy exposed charcoal to intense ignition *in vacuo*, and in condensed azote, by means of Mr. Children's magnificent battery, when it slowly volatilised, and gave out a little hydrogen. The remainder was always much harder than before, and in one case so hard as to scratch glass, while its lustre was increased. This fine experiment may be regarded as a near approach to *the production of the diamond* (see also the accounts of the Diamond in *Things not generally Known*, pp. 200-203; *Popular Errors Explained and Illustrated*, pp. 55-56).

The composition of this gem is undoubtedly carbon, seeing that the sole result of its combustion in oxygen is carbonic-acid gas; but the origin of the Diamond is a subject of much curious speculation. Seeing that its structure is crystalline, the Diamond should have been, at some early period, in a liquid or semi-liquid condition, a state which presupposes fusion by fire, or solution in some menstruum. Opposed to the first hypothesis is the circumstance that within the structure of many Diamonds are seen the remains of organic beings, appearances scarcely consistent with the assumption that the Diamond was once in a state of igneous liquidity. Sir David Brewster inclines to the opinion that the Diamond is a drop of fossilised gum.—*Faraday.*

FORMATION OF DIAMONDS.

The establishment of the identity of Carbon and the Diamond soon led persons to anticipate the time when our home manufactures should rival the produce of Golconda. In such speculations it is but reasonable to take into account the reflection with which Mrs. Somerville closes the following passage: "It had been observed that when metallic solutions are subjected to galvanic action, a deposition of metal, generally in the form of minute crystals, takes place on the negative wire. By extending this principle, and employing a very feeble voltaic action, M. Becquerel has succeeded in forming crystals of a great proportion of the mineral substances, precisely similar to those produced by nature. The electric state of metallic veins makes it possible that many natural crystals may have taken their form from the action of electricity bringing their ultimate particles, when in solution, within the narrow sphere of molecular attraction, which is the great agent in the formation of solids. Both light and motion favour crystallisation. Crystals which form in different liquids are generally more abundant on the side of the jar exposed to the light; and it is a well-known fact that still water, cooled below thirty-two degrees, starts into crystals of ice the instant it is agitated. Light and motion are intimately connected with electricity, which may therefore have some influence on the laws of aggregation: this is the more likely, as a feeble action is alone necessary, provided it be continued for a sufficient time. Crystals formed rapidly are generally imperfect and soft; and M. Becquerel found that even years of constant voltaic action were necessary for the crystallisation of some of the hard substances. If this law be general, *how many* ages may be required for *the formation of a Diamond?*"

Simmler suggests that Diamond may possibly be a product of crystallisation from liquid carbonic acid. Diamond often contains cavities; and, as Sir David Brewster has observed, with accompanying circumstances which point to a strong pressure in the interior, although he does not state whether they contained water.

Brewster explained his observations of the coloured rings with the black cross around the cavities by ascribing to the diamond a gummy consistence and vegetable origin. Simmler suggests that it may rather be compared to that of unequally compressed glass.

To confirm this view of the formation of diamonds, it would be necessary to prove that liquid carbonic acid possessed a solvent power for carbon similar to that which bisulphide of carbon has for sulphur, or liquid sulphide of phosphorus for phosphorus. Experiments which Simmler made in this direction, with a view of preparing liquid carbonic acid by Faraday's method, gave no results, as the tubes always exploded.—*Philosophical Magazine*, No. 114.

The old notion that " Diamonds grow " has lasted to our own time. When Dr. Buchanan visited the diamond-mine of Panna in India, the workmen assured him, " that the generation of diamonds is always going forward, and that they have just as much chance of success in searching earth which has been fourteen or fifteen years unexamined as in digging what has never been disturbed ; and, in fact, he says, I saw them digging up earth which had evidently been before examined." M. Voysey, who visited some of the principal diamond-mines of Southern India in 1821, confirms the statement of Dr. Buchanan, that the diamonds are supposed to grow in the old rubbish that had been previously examined. Nay, the truth of this opinion may be considered as demonstrated by the fact, that the miners no longer quarry fresh breccia from beneath the sandstone, but " are content with sifting and examining the old rubbish of the mines," and in which they actually find diamonds. The opinion that diamonds grow in the previously washed, sifted, and examined rubbish, and that the chips and small pieces rejected by former searchers actually increase in size, and in process of time become large diamonds, prevails every where in India ; and even at Grani Parteal or Couloure, where the great Koh-i-noor was found, the search is confined to the rubbish of the old mines.

M. Voysey, who was geologist to the Indian Trigonometrical Survey, adds the important observation, that in hot climates crystallisation goes on with wonderful rapidity, and that he hoped at some future period to produce undeniable proofs of the recrystallisation of amethyst, zoolite, and feldspar in alluvial soil ! Unfortunately for science, M. Voysey died soon after the above was printed.

NEW DIAMOND.

MM. Wohler and Deville have made experiments upon Boron, from which it appears that it can exist in three states, exactly corresponding to those of carbon, viz. the amorphous, the graphitic, and the crystallised state. In order to obtain the latter, 100 grammes (3½ ounces) of boric acid and eighty of aluminium are exposed, during five hours, to a violent fire in a black crucible coated with charcoal-powder. The mass is then left to cool, and on breaking the crucible, two distinct strata come to view—one consisting of vitrified Boric Acid, or Boracic Acid containing some alumina; and the other of aluminium in a metallic state, mixed up with crystals of boron. To separate the latter, this metallic mass is treated with boiling caustic soda to dissolve the metal; then with boiling hydrochloric acid to carry off the iron which may have been separated from the plumbago of the crucible; and lastly, with a mixture of nitric and hydrofluoric acid, to dissolve the silicium left by the soda. After this, the boron is obtained pure, in three varieties of crystals, viz.—1, black and opaque laminæ, which will cut diamond, though not so well as diamond-powder: 2, long prismatic crystals, perfectly transparent and as brilliant as diamonds, but not so hard as the former variety; if without flaws, they might be used for jewelry; 3, very minute but distinct crystals of a red chocolate colour, and quite as hard as diamond; they may be used as diamond-powder, and give a fine polish.

WHAT PRECIOUS STONES ARE MADE OF.

First, as to the Diamond, which, though the king and chief of all, may be dismissed in two words—pure carbon. The diamond is the ultimate effort, the idealisation, the spiritual evolution of coal—the butterfly escaped from its antenatal tomb, the realisation of the coal's highest being. Then the Ruby, the flaming red Oriental Ruby, side by side with the Sapphire and the Oriental Topaz—both rubies of different colours—what are they? Crystals of our commonest argillaceous earth, the earth which makes our potter's clay, our pipe-clay, and common roofing-slate—mere bits of alumina. Yet these are among our best gems, these idealisations of common potter's clay. In every 100 grains of beautiful blue Sapphire, ninety-two are pure alumina, with one grain of iron to make that glorious blue light within. The Ruby is coloured with chromic acid. The Amethyst is only silica or flint. In 100 grains of amethyst, ninety-eight are simple pure flint—the same substance as that which made the old flint in the tinder-box, used before our phosphorus and sulphur-headed matches; and which, ground up and prepared, makes now the vehicle of artists' colours. Of this same silica are also Cornelian, Cat's-eye, rock crystal, Egyptian Jasper, and Opal. In 100 grains of opal, ninety are pure silica and ten water. It is the water, then, which gives the gem that peculiarly changeable and iridescent colouring which is so beautiful, and which renders the opal the moonlight queen of the kingly diamond. The Garnet, the Brazilian—not the Oriental—Topaz, the Occidental Emerald, which is of the same species as the Beryl, all these are compounds of silica and alumina. But the beryl and emerald are not composed exclusively of silica and alumina : they contain another earth, called glucina—from *glukos*, sweet, because its salts are sweet to the taste. The Hyacinth gem is composed of the earth, not so long discovered, called zirconia, first discovered in that species of hyacinth stone known as zircon. The zircon is found in Scotland. To every 100 parts of hyacinth seventy are pure zirconia. A Chrysolite is a portion of pure silicate of magnesia. Without carbonate of copper there would be no Malachite in Russia or at the Burra Burra mines ; without carbonate of lime there would be no Carrara marble ; the Turquoise is nothing but a phosphate of alumina coloured blue by copper ; and the Lapis Lazuli is only a bit of earth painted throughout with sulphuret of sodium.

CARBONIC OXIDE.—CARBONIC ACID.

Professor Dumas has illustrated the great, and indeed almost unsurpassed, influence of carbonic-oxide gas. The judicial investigations in France have disclosed the fatal effects of this gas as being much greater than carbonic-acid gas. In the atmosphere produced by the burning of charcoal, $\frac{1}{200}$ part of carbonic oxide was fatal, while with one-third the volume of carbonic acid the animal was asphyxiated, but afterwards revived.

The volume or bulk of carbonic-acid gas expired by a healthy adult in twenty-four hours is said to amount to 15,000 cubic inches, containing about *six ounces* of solid carbon. This is at the rate of 137 pounds avoirdupois per annum ; and taking the total population of the globe at seven hundred and sixty millions, the amount of solid carbon or charcoal every year produced by the human race will exceed 46,482,143 tons! Adding to this all the carbon produced by the combustion of fires and gas-lights, by the decay of animal and vegetable matter, the exhalations from springs, &c., there need be no marvel as to the source whence plants derive their solid or woody material (which is principally carbon), seeing that their leaves are specially fitted for the absorption of carbonic-acid gas from the surrounding atmosphere.

On the lowest calculation, the population of London must add to the atmosphere daily 4,500,000 pounds of carbonic acid.

It is supposed that from the enormous quantity of carbonic acid which appears from time to time in the atmosphere of the

New World, and from the large number of volcanoes that exist in the country, that a portion of the carbonic acid of the air in other countries is due to them, and that they thus contribute in part to nourish the vast and beautiful vegetation of the Tropics.

LIQUID AND SOLID CARBONIC ACID.

The means employed by the discoverer (Faraday) for reducing gases into fluids are of admirable simplicity. A simple bent tube, or a reduction of temperature by artificial means, has superseded, in his hands, the most powerful compressing engines.

When sulphuric acid is poured upon limestone in an open vessel, carbonic acid escapes with effervescence as a gas; but if the decomposition be effected in a strong, close, and suitable vessel of iron, we obtain the carbonic acid in a state of liquid.

Its properties are very curious. When a small jet of it is permitted to escape in the atmosphere, it assumes its gaseous state with extraordinary rapidity, and deprives the remaining fluid of heat so rapidly that it congeals into a white crystalline mass like snow: this is pure frozen carbonic acid, with a temperature of at least 144° Fahrenheit below that of freezing water.

When exposed to the air, nay, when thrown into a red-hot capsule, this snow-like carbonic acid retains, while continually evaporating, its solid form (in that portion which has not yet evaporated); and so long as it retains its solid form, it retains also its low temperature (its melting-point). The more rapid addition of heat hastens its evaporation, but produces no other change on the portion which remains solid.

If we handle solid, snow-like carbonic acid, we perceive but little of its intense cold, because its light, spongy, porous structure, like that of dry flakes of snow, offers very few points of contact with the skin, and hence can withdraw from it but little of its heat.

But if we press the solid acid with some force on the skin, the circulation of the blood is arrested at the point touched, as by a metal at a dull red heat; a white spot appears, which in fifteen seconds becomes a blister, and in two minutes a white depression is formed, followed by suppuration and healing, a scar being left.

The solid carbonic acid communicates to ether its very low temperature; and if the mixture be placed upon mercury, it (the metal) will become in a few minutes solid and malleable.

When the mixture of ether and solid carbonic acid is placed in the vacuum, the increased and accelerated evaporation produces so intense a degree of cold (from 180° to 200° below the freezing-point of Fahrenheit), that most of the compound gases become liquid when exposed to it, and several are frozen.

If you put the mixture of ether and solid carbonic acid into a red-hot crucible, it will require for its conversion into gas as much time as it would in the air at the ordinary temperature; and if you introduce into the mixture, in a vessel of ordinary temperature, or in the red-hot crucible, a small tube containing mercury, the mercury freezes and becomes solid.*

SULPHUR IN HAIR AND WOOL.

The proportion of Sulphur in Hair and Wool is very large; and as they are daily growing, they necessarily draw upon and rob the land of sulphur, its especial constituent. Professor Johnston, in his *Elements of Agricultural Chemistry and Geology*, states that the wool which is grown in Great Britain and Ireland carries off the land every year upwards of 4,000,000 of pounds of sulphur, to supply which would require the addition to the soil of 300,000 tons of gypsum. Things that appear trifling to us when viewed in the small way in which we actually see them, become important when considered in the large scale in which they take place in nature. The hair on the heads of our population carries off nearly half as much as the wool of our sheep: it is not without reason, therefore, that the Chinese collect, and employ as a manure, the hair shaven every ten days from the heads of their people.—*North British Review*, No. 6.

Professor Bailey states, in *Silliman's Journal*, that with the nitroprusside of soda he has detected the presence of sulphur in the smallest portion of coagulated albumen, horn, nails, feathers, &c. supported on a platinum-wire for blowpipe experiments; and he has often obtained the beautiful purple tint in operating upon a piece of a single fibre of the human hair less than one inch in length.

SULPHUR IN BOILED EGGS.

It is well known that silver, when brought in contact with eggs which have been heated, is blackened, and that this discoloration is owing to the sulphuret of silver. It is usually admitted that this sulphuret is formed by the action of the sulphuretted oils supposed to exist in the yolk of the egg. M. Gobley, not having found in this body any thing of this nature, has examined the causes of the phenomenon: he finds that the yolk of an egg at the common temperature, and also when heated, does not discolour silver, even by several hours' contact. He further finds that albumen, as procured from the egg, does not tarnish silver, but when heated it gives it a brown tint, which is stronger as the heat is greater. He therefore concludes that the discoloration of the silver is due to the sulphur contained in the albumen, and not to that supposed to exist in the yolk. By other experiments he has ascertained that the sulphuret thus formed is not the result of the immediate action of the sulphur upon the silver, but by the application of heat the sulphur and the alkali of the albuminous matter react upon each other so as to form a substance which is afterwards decomposed by this metal.

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* The late Sir Isambard Brunel for ten years carried on experiments in constructing a machine for using carbonic-acid gas as a motive power.

PHOSPHORUS.

It is now nearly two centuries since Brandt, the Hamburgh alchemist, in his search for gold, accidentally discovered the elementary body Phosphorus, named, from its property of being luminous in the dark, from two Greek words, *phos*, light, and *phero*, I bear. Within two years of this discovery, or in 1670, one Kraft brought a small piece of phosphorus to London, and showed it to Charles II. and his Queen, the year after peace was concluded with Holland. The Hon. Robert Boyle afterwards discovered the process, which he described in the *Philosophical Transactions* for 1680, and in a small work which he published in the same year, entitled the *Aerial Noctiluca*. Mr. Boyle instructed Mr. Godfrey Hankwitz of London how to procure phosphorus from urine, so that he was the first who made it for sale in England; and he is said to have supplied all Europe with it for many years. It continued long to be an expensive chemical: for in 1731 we find by the books of the Royal Society that for Dr. Frobenius's experiments on the Transmutation of Phosphorus, exhibited before the Prince of Wales, the phosphorus used on the occasion, amounting to six ounces, cost ten guineas!

Phosphorus has since been known as a dangerous combustible and most deadly poison.

Since about 1660 (says Dr. G. Wilson) we have been familiar with Phosphorus as a soft, semi-transparent, nearly colourless, wax-like substance, possessed of a glassy structure, exhaling in the air an odour of garlic, shining at the freezing-point of water, melting a hundred degrees below the boiling-point (111·5° F.) of that liquid, bursting into flame in the air at a temperature a little higher, and yielding a thick white smoke, condensing into a snow of phosphoric acid. This form of the element we have learned to distinguish as vitreous phosphorus. It is so inflammable that it can be preserved with safety only under water, and there is scarcely a chemist who has not been in some degree a martyr to its flames. It is so poisonous that not a year passes without some poor child falling a victim to the minute portion which it thoughtlessly eats from a lucifer-match, and without uncautioned lucifer-match makers suffering the prolonged torture of slow poisoning, which its daily administration in infinitesimal doses infallibly occasions. It reacts so powerfully upon the air in which it is permitted to fume, that it changes its oxygen into the energetic, oxidising, deodorising, and bleaching agent which is known as ozone. In a word, it exhibits in an intense degree an affinity, or tendency to combine, alike with metals and non-metals, and strikingly alters each by its union with it.—*Edinburgh Essays,* 1856.

Vitreous Phosphorus is susceptible of these modifications : 1. From the glassy to the crystalline condition. 2. By exposure under water to air and light, it becomes a *white,* opaque body. 3. By fusion, heat, and sudden cooling, black and opaque. 4. By heat and sudden cooling, viscid like sulphur, and in consistence like caoutchouc. 5. An amorphous *red* solid.

Phosphorus, however, when prepared red, or amorphous, is much less fusible than common phosphorus. This red phosphorus is not poisonous, even when directly administered in doses a hundred times greater than those which are fatal with vitreous phosphorus ; it may be handled with impunity ; and by Schrötter's process of preparing it, the manufacture, use, and carriage of lucifer-matches made with it are much less dangerous than formerly. Messrs. Allbright, near Birmingham, have for several years prepared this red phosphorus on a large scale. The common phosphorus is derived from calcined bones, by treating them with sulphuric acid and water ; and it is rendered amorphous by exposing it for fifty hours to a temperature of about 500° in an atmosphere which is unable to act chemically upon it.

The Lucifer Match was invented in 1827, by Mr. John Walker, a chemist and druggist, of Stockton-upon-Tees. He was preparing with phosphorus some lighting mixture for his own use, when by accidental friction on the hearth of a match dipped in the mixture a light was obtained. The hint was not thrown away. Mr. Faraday, it is said, first brought the discovery into practice. Mr. Walker died in 1859, aged seventy-eight.

The *Bolognian Phosphorus,* one of the most powerful of the solar phosphoric substances, had a curious origin. It was the accidental discovery of Viscenzio Cascariolo, a shoemaker, of Bologna, who, about the year 1630, being engaged in some alchemical experiments, had occasion to calcine a quantity of active sulphate of barytes, found near Bologna at Monte Paterno. He observed that whenever this mineral had been sufficiently heated, it acquired the property of shining in the dark after having been exposed to the sun's rays, and that it would even continue thus to emit light for some hours. The best mode of preparing this substance became a subject of no small pecuniary importance, and a family of the name of Zagoni appear to have been the most successful preparers of it.

NICE ESTIMATE OF LIGHT.

Mr. Faraday and M. Becquerel. to show that fluorescence and phosphorescence are luminous conditions differing only in the *time* of their continuance, employ the *Phosphoroscope*, the cylinder of which revolves 300 times in a second, showing a phosphorescent effect which lasts only the $\frac{1}{3000}$, or even the $\frac{1}{8000}$ of a second.

Several times Mr. Faraday has observed that a flash of lightning, when seen as a linear discharge, left the luminous trace of its form on the cloud, enduring for a sensible time after the lightning was gone; the true explanation of which Mr. Faraday considers to be the phosphorescence of the cloud.

An instrument has been constructed for producing isolated luminous impressions, varying from one-tenth to one-millionth of a second.

UBIQUITY OF IODINE.

Iodine, thus called on account of its violet colour, from the Greek word *iodos*, was accidentally discovered by M. Courteois, a manufacturer of saltpetre, at Paris, in 1812. In his process for procuring soda from the ashes of sea-weed, he found the metallic vessels much corroded, and in searching for the cause he made the important discovery.

Sir Humphry Davy tried to decompose iodine, but he failed in his subtle analysis; and to the present day iodine is considered as a simple body—one of the primitive elements of our terrestrial world.

Where do we find iodine? a little every where and in every thing, but generally a very small proportion. All the fishes, shells, sponges, and ocean weeds yield iodine; and the wrack-grass, those fuci which the boiling and rolling of the waves deposit upon the barren shores, seemed to be useless refuse, but are now known to yield a useful substance in pharmacy and the arts. Iodine has the property of dissolving the gland of goitre and cretinism, and is the principal agent in Photography.

Thus, we find evidence of the existence of iodine in marine and fresh-water aquatic plants from all quarters of the globe. Fermented liquors contain iodine: wine, cider, and perry are more ioduretted than the average of fresh waters. Milk is richer in iodine than wine; independently of the soil, with which it varies, the proportion of iodine in milk is in the inverse ratio of the abundance of that secretion. Eggs (not the shell) contain much iodine: a fowl's egg weighing fifty grains contains more iodine than a quart of cow's milk. Iodine exists in various soils. It is abundant in sulphur, and in ores of iron and manganese, and sulphuret of mercury; but rare in gypsum, carbonates of lime, and siliceous earths. Any attempt to extract iodine economically should be made from fuci. Most of the bodies regarded by the therapeutists as pectoral and antiscrofulous are rich in iodine. To sum up, M. Chatin shows that iodine has been detected in the waters of the ocean, lakes, and springs; in the solid crust of the earth in various mineral compounds; in many plants,* chiefly, if not entirely, aquatic; in animals; as an ingredient in the earth's atmosphere, as in rain, dew, and snow. The test admits of extraordinary delicacy: Dr. Price has detected the $\frac{1}{4000000}$ part of iodine dissolved in water as iodide of potassium.

Iodine stains the skin, but not permanently; it has a very energetic action upon the animal system, and is much used in medicine. One of its most characteristic properties is the production of a splendid blue colour in contact with the organic principle starch.

EARLY GAS-LIGHTING.

Soon after the establishment of the first gas-works at Westminster, in 1810-12, an extensive explosion took place on the premises, when a committee of the Royal Society was, at the request of the Government, appointed to investigate the matter. They met several times at the gas-works to examine the apparatus, and made a very elaborate report, in which they stated as their opinion, that if gas-lighting was to become prevalent, the gas-works ought to be placed at a considerable distance from all buildings, and that the reservoirs should be small or numerous, and always separated from each other by mounds of earth or strong party-walls! Some sixty years before, in 1753, Sir James Lowther described to the Royal Society a curious notice of a spontaneous evolution of gas at a colliery near Whitehaven. It annoyed the workmen so much that a tube was made to carry it off. Sir James states that parties were in the habit of filling bladders with the gas, and burning it at their convenience. It appears strange that this hint did not bring gas-lighting into use earlier.—*Philos. Trans.* vol. 38. (See "Progress of Gas-lighting," *Things not generally Known*, First Series, p. 198.)

UNWHOLESOMENESS OF LIGHTS.

Recent experiments have proved that Lights of equal intensity, obtained from different materials, require very different lengths of time to generate the same quantity of carbonic acid. The following is the relative time required by common materials: Olive-oil, 72 minutes; Russian tallow, 75; common (French) tallow, 76; whale-oil, 76; stearic acid, 77; wax candles, 79; spermaceti, 83; gas from common coal, 98; gas from cannel coal, 152 minutes. Coal-gas, therefore, and especially gas from cannel coal, is the least unhealthy of all ordinary lights, which is contrary to the usual opinion.

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* Nearly fifty years since, the writer remembers the pulp of sea-weed as a popular remedy for the spine and limbs of weak and rickety children, much in use at Brighton and other watering-places, long before the existence of Iodine in marine plants had become generally known.

EFFECTS OF CARBURETTED HYDROGEN ON PLANTS.

A collection of exotic plants in a green-house in Philadelphia was, through the breakage of the city "mains," and the consequent leakage of a large quantity of gas, exposed to its deleterious influence. The plants, numbering nearly 3000, were almost entirely ruined. Those in leaf did not suffer, nor did a row of maple-trees immediately over the leak; the injury sustained being entirely through their breathing organs. The general sympathy known to exist between the genera of the same natural order extends to the action of this deleterious substance upon them. The beautiful *Amantiaceæ* were so keenly sensitive to the poison that even large old specimens were stripped at once. The floor was covered with leaves, and oranges and lemons in all stages of growth, from fruit first formed to that fully matured. The trees, by careful pruning and nursing, were somewhat restored. *Camelliæ* were in full bloom, in about 120 varieties; not a leaf, bud, or flower remained upon the largest and the finest plants.

CHEMICAL EFFECTS OF INTERMENT IN VAULTS AND CATACOMBS.

Although much had been said and written on the decomposition of the human body after interment in the earth, but little was known until lately respecting the process and results of such decomposition when modified by the corpse being placed in a vault or catacomb.

In 1849 and 1850, Mr. Walter Lewis, by direction of the General Board of Health, visited the vaults of the principal churches of London, noted the external appearance of more than 22,000 coffins, and the contents of nearly 100, and several times tested or analysed the atmosphere of the vaults. In no case did he discover the slightest trace of cyanogen, hydrocyanic acid, or phosphuretted, sulphuretted, or carburetted hydrogen, except a very minute quantity of sulphuretted hydrogen in the air of a single vault, which contained but few coffins. The corroded parts of old leaden coffins were always found to be carburet of lead, with no trace of sulphate or sulphuret. Some of the coffins contained ammoniacal gas in large quantities, and others none at all; but, with this exception, the contained air was nearly alike in all, being composed of nitrogen, carbonic acid, common air, and animal matter in suspension. When ammonia was present, it overcame every other odour; when absent, the smell resembled that of very putrid moist cheese. The result was the same, whether the interment had been made a few weeks or a century and a half previously, whatever the cause of the disease, or the age at which it took place. Out of all the coffins examined, but twenty of the leaden ones had been bulged by the pressure of the gases in the interior. This is only about one out of a thousand, and shows that the gases are formed very slowly. Mr. Lewis, from various inquiries, could not ascertain that a coffin had ever been known to burst suddenly from the pressure of the confined air. When one becomes bulged, it is customary for the sexton to make a small aperture in it, to which is applied a torch as an antidote to the noxious effect of the escaping gases. Several persons whom Mr. Lewis had consulted had heard of cases in which the gases caught fire, but, after searching inquiry, he could not find one who had ever seen them burn.

Mr. Lewis infers from the experiments made by him in vaults and catacombs, that the deleterious emanations from these depositories may continue for a hundred years after they are closed; they are not rendered noxious by poisonous gases generated during the process of decomposition, but by the animal matter itself, with which, if ventilation is not allowed, the air becomes saturated; that nitrogen and carbonic acid, holding animal matter in suspension, steadily but quietly make their way through the pores of lead coffins, and by the same means to the open air, so that, at the end of fifty or a hundred years, nothing remains but a few dry bones, though the coffins are still sound and unruptured.

Mr. Lewis, in conclusion, recommended that "interments in vaults and catacombs be no longer permitted, as they are but so many active volcanoes, constantly emitting poisonous effluvia; and that the use of leaden coffins should be entirely discontinued."—*Abridged from the Lancet*, 1851.

Mr. R. V. Tuson, in the *Philosophical Magazine* for April 1860, maintains that the substance obtained, as above, from leaden coffins is carbonate of lead—that it is anhydrous, contains but a small excess of oxide, and hence differs in composition from other carbonates of lead. It was found, during the search for the remains of John Hunter in 1859, in the vaults of the church of St. Martin's-in-the-Fields, that many leaden coffins had been converted, interiorly, all but a thin outer plate or foil, into this carbonate.

See also "How soon a Corpse decays," *Curiosities of Science*, First Series, p. 237.

VINOUS FERMENTATION.

In making wine, no yeast or other ferment is added to the must; but vinous fermentation ensues from the action of certain nitrogeniferous principles existing in the grape-juice, which confers upon them the properties of yeast. Hence it has been asked why the juice of the grape does not ferment in the grape itself; and how it is that ripe grapes, even when cut from the vine, not only exhibit no such tendency, but, as long as the skin is entire, shrivel up into *raisins.* This anomaly was hypothetically solved by assuming that the gluten or ferment was shut up in distinct vesicles, which, on mashing or pressing the fruit, were ruptured, and so became active. But Gay Lussac found that when thoroughly bruised grapes were carefully excluded from the air, or rather, when the grapes were crushed and pressed out of the presence of oxygen, no change ensued; but that even a momentary exposure of the pulp to air or oxygen was sufficient to endue it with the power of fermentation.

It is curious to observe how admirably the exclusion of air is provided for by the natural texture of the grape, which does not allow its ingress, and yet admits of the egress or transpiration of aqueous vapour, as shown by the spontaneous desiccation of the berry.—*Brande's Lectures, abridged.*

These Lectures "on some of the Arts connected with Organic Chemistry," were delivered by Professor Brande, at the Royal Institution,* in the spring of 1852. At their close, Mr. Brande resigned his professorship, having been officially attached to the Institution for a period of forty years, or since 1812, when he succeeded to the chair vacated by Sir Humphry Davy. "Looking at the Royal Institution (said Mr. Brande), I revere it as my *alma mater*, where, as a schoolboy, I listened to the fruitful eloquence of Davy, and afterwards partook of his acquaintanceship and friendship; where I acquired the patronage of Sir Joseph Banks; where I was singled out by Wollaston as his successor in the secretaryship of the Royal Society; where I came into frequent contact with the chiefs of science and of literature and art; where Faraday became my pupil, my colleague, and my friend,—these, I assure you, are only a very few of the proud and pleasing reminiscences which accompany me from this place; and they are unsullied and unalloyed. They have never been clouded, tainted, or embittered. I again, therefore, thank you for all your partiality and kindness; and in gratitude to Providence, in whose merciful hands are all the issues of our lives, I respectfully beg you to accept my affectionate farewell."

VEGETABLE FERMENTATION.

Mitscherlich, of Berlin, believes fermentation to be brought about by the vital action of vegetable cells in a state of growth or development. Thus, the vegetable cells found in fermenting beer are apparently of two kinds, and belong to the lowest forms of vegetable life. It is supposed that, through the agency of the vegetable cells, the sugar is decomposed, the carbonic-acid gas formed, and alcohol and water developed. The ultimate action, however, in the vegetable cell is due to catalysis, or to that modification of this force which Liebig calls molecular motion. For every germinating vegetable cell consists, first, of a quantity of matter—such as starch and sugar —without nitrogen; and secondly, a body containing nitrogen called *diastase*. This latter acts as a ferment during germination, and the results are nearly the same; the sugar, starch, &c. being decomposed, and one of the results the formation and disengagement of carbonic-acid gas.

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* The Royal Institution has been worthily designated "the workshop of the Royal Society." The history of chemical science dates one of its principal epochs from the establishment of the laboratory of the Royal Institution. Here the researches of Davy and Faraday extended over half a century; including the laws of electro-chemical decomposition, the decomposition of the fixed alkalies, the establishment of the nature of chlorine, the philosophy of flame, the condensibility of many gases, the science of magnetic electricity, the twofold magnetism of matter, and the magnetism of the gases. The mineralogical collection in the museum was commenced by Davy; and in the library are preserved the great chemist's laboratory note-books.

COMBUSTIBILITY OF GASES.

The combustibility of gases is, to a certain extent, in direct proportion to the masses of heated matter required to inflame them. A red-hot wire one-fortieth of an inch in diameter will not ignite olefiant gas, but it will inflame hydrogen gas; and the same wire heated white-hot will inflame olefiant gas, but will not inflame the carburetted-hydrogen gas of the coal-mines, which, fortunately, is the least combustible of all the inflammable gases.—*Sir H. Davy.*

ABSORPTION OF GASES BY CHARCOAL.

When we had ascertained the fact of gases becoming fluid under the influence of cold or pressure, a curious property possessed by charcoal, that of absorbing gases to the extent of many times its volume,—ten, twenty, or even, as in the case of ammoniacal gas or muriatic-acid gas, eighty or ninety fold,—which had been long known, no longer remained a mystery. Some gases are absorbed and condensed within the pores of the charcoal into a space several hundred times smaller than they before occupied; and there is now no doubt they there become fluid or assume a solid state. As in a thousand other instances, chemical action here supplants mechanical forces. *Adhesion*, or heterogeneous attraction, as it is termed, acquired by this discovery a more extended meaning. It had never been before thought of as a cause of change of state in matter; but it is now evident that the adhesion of a gas to the surface of a solid body is a process opposite to that of solution. —*Liebig.*

WHAT IS DONE WITH THE GASES?

One species, or rather a variable mixture of two or three, composed of carbon and hydrogen, is made in the outskirts of nearly every town nowadays in enormous quantities, and then sent away from a huge trough or jar, or from a heart, to circulate through a system of metallic arteries for the purpose of lighting streets and houses. Hoffman's spirit of charcoal, the fixed air of Black, the carbonic acid of the present nomenclature, is studiously crushed into bottles of soda-water by stout machinery, to be quaffed by the luxurious and the ailing before it has time to fly away. Our cottons and linens are bleached by chlorine. Great balloons are filled with the phlogisticated air or hydrogen of Cavendish, the lightest of corporeal bodies, to carry men of science and fools with singular impartiality. Oxygen and hydrogen are separated from chemical union with one another in water, suffered to remain mechanically mingled, and then made to unite by combustion at the nozzle of the oxyhydrogen blowpipe, so as to produce beautiful and useful results. The arsenic that may lurk about the putrid remains of a dead and buried man is transformed by an easy process into arseniuretted-hydrogen gas, so as by its decomposition to bring the metal that laid him low before the eye of a jury. The spirit of hartshorn is now understood to be but a compound of nitrogen and hydrogen, called ammonia, absorbed by and probably in combination with water; while the old spirit of salts, or muriatic acid, is just an aqueous solution of hydrochloric gas. The nitrogen is seduced into something like an unwilling chemical union with the oxygen of the atmosphere, by a device borrowed from nature, so as to yield the nitrate of lime, the nitrate of potassa or saltpetre, the nitrate of soda, and (by a secondary process) the nitric acid or nitrate of water itself, that invaluable oxidant and solvent of the metallurgist and the chemist.* In fact, there is no end to the application of this pneumatic chemistry, which took its rise from the mind of Joseph Black, who lived as fine a life of science as was ever lived, and died with a cup of milk unspilt in his hand.—*North British Review*, No. 35, abridged.

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* Nitric acid will entirely dissolve bone and flesh, both disappearing without any smell. Professor Horsford, of the United States, considers that it would take rather more nitric acid than the weight of the whole flesh and bone to dissolve a human body.

Chemistry of Metals.

TRANSPARENCY OF METALS.

Opacity is an almost universal characteristic of metals, as we see them; but gold has been beaten into leaves so fine as to become partially transparent,—not in consequence of any cracks, holes, or fissures, but by the shining of light through its substance. These leaves are 1-200,000th of an inch in thickness. The light transmitted is green, although the incident ray is white; thus negativing the supposition of a mere passage through orifices in the gold, and proving the metal to possess a true refractive power, unequal for different colours of light, as is the case with most transparent media. Silver-leaf only 1-100,000th of an inch in thickness is perfectly opaque.

The above phenomenon of gold renders the supposition probable that other metals might also become transparent, provided they were sufficiently malleable to be beaten out into leaves of the necessary fineness; and thus we are obliged to relinquish the idea of opacity as being necessarily a quality of metallic bodies.—*Faraday.*

RUST A PROTECTOR.

All the common metals, except tin (says Faraday), rust; they become duller and duller up to a certain degree, lose gradually their lustre, and then the process goes no farther. Instead of the rusting being a destroyer of the metal, it is a preserver; for even in the case of iron, which rusts quickly as compared with other metals, if it be dipped into tin, it comes out coated with it, and is preserved beautifully. If iron be exposed for a couple of hours to the action of water, the iron becomes quite corroded; but when tinned, the iron is protected, and the tin itself is not affected. How is it that this metal can protect itself, and the iron that is under it? It is simply owing to the substance formed on the surface by the attraction of oxygen, which is so adherent to the metal beneath. It gives a protection which no varnish nor any kind of application can afford. Take a copper or a tin plate; they are both protected in their metallic state by a thin coat formed in the first instance of oxide. It is only because this coat is so exceedingly compact, close, and adherent, that it passes for nothing—a mere film of tarnish. You think you see or touch a piece of tin; you cannot detect the film except by close examination. We know it is there; but it is only by optical phenomena that we can measure its thickness. It seems clear and beautiful, but if you rub it off, you give the metal beneath a new character; the lustre, however, passes off the first moment up to a certain point. The body formed by the combination of oxygen with iron is different. The oxide does not adhere to the metal beneath; it forms upon it little spots, or porous tumuli. It is not an investing varnish; but the process goes on through the pores of the rust, especially if the metal be placed in a damp atmosphere. This is the reason why we find a difference between copper, iron, tin, and lead, when used for roofs, or other external purposes. The iron alone is eaten into and destroyed by this want of adhesion in its rust to the surface of the metal.

It is curious to observe, in some cases, how tin, as metal having a slight attraction for oxygen, protects other metals from oxidation. In Canada, tin-plate is used for the roofs of houses: you are dazzled by the lustre of the sun acting upon the roofs; and there, although it is exposed to the atmosphere year after year, it does not decay, because the superficial coat of oxide protects the tin and iron beneath.

ANTIMONY.

We have already adverted to the high appreciation of this metal by the Alchemists (see page 12). Here is a beautiful experiment:

> On electrolysing a solution of terchloride of antimony (one part of tartar-emetic in four parts of ordinary chloride of antimony) by a small battery of two elements, metallic antimony forming the positive, and metallic copper the negative pole, crusts of antimony are obtained, which possess the remarkable property of exploding and catching fire when scratched or broken.—*Gore; Proceedings of the Royal Society*, vol. ix.

Besides its application to medicine, antimony is of great importance in the arts, inasmuch as it forms with lead *type-metal*. This alloy expands at the moment of solidifying, and takes an exceedingly sharp impression in the mould. It is remarkable that both its constituents shrink under similar circumstances, and make very bad castings.

Tersulphide of antimony is employed in the Bengal or blue signal-light used at sea, as follows: dry nitrate of potassa, six parts; sulphur, two; tersulphide of antimony, one.

To show how little the early chemists understood of the distinction between organic and inorganic or mineral substances, it is recorded that they classified chloride of antimony (butter of antimony) next to the butter of the cow!

ARSENIC.

Arsenic is first mentioned in the works of Dioscorides, but is there thought to have been the well-known paint orpiment. Though long known, it was first examined with tolerable precision by Brandt, in 1733. It is very frequently met with in nature, sometimes in its pure metallic state of steel-gray colour, and considerable brilliancy, which it soon loses on exposure to the air, and becomes black on the surface; the artificially obtained metal not only suffers these changes, but falls to powder by the action of the air, and in this state is known on the Continent as *fly-powder*. When kept under water, arsenic undergoes no change; if heated to 356° Fahr. it is volatilised without previous fusion; the vapour has the odour of garlic, which is relied upon as a proof of its presence. This substance combines with metals in the same manner as sulphur and phosphorus, which it resembles, especially the latter. With oxygen it unites, giving rise to arsenious and arsenic acids.

Arsenic in the oxidised state is found in minute quantities in many mineral waters. It is mostly derived from roasting natural arsenides of iron, nickel, and cobalt; the volatile products being condensed in a chimney divided into chambers.

Of the various Poisonings by Arsenic we shall speak in a future page.

SILVER.

Silver is found principally in the mines of the Harz mountains in Germany, Königsberg in Norway, and the Andes in North and South America. It is mostly extracted from poor ores, not by smelting, but by amalgamation, as silver and many other metals are easily soluble in metallic mercury. Pure silver is probably the best conductor of heat and electricity known. In hardness it lies between gold and copper. Silver is unalterable by air and moisture; it refuses to oxidise at any temperature, but possesses the extraordinary faculty of absorbing many times its volume of oxygen when heated strongly in an atmosphere of that gas, or in common air. The oxygen is again disengaged in the appearance often remarked on the surface of masses or buttons of pure silver. The addition of 2 per cent of copper is sufficient to prevent this absorption of oxygen. Silver oxidises when heated with fusible siliceous matter, as glass, which it stains yellow or orange, from the formation of a silicate. The tarnishing of silver exposed to the air is due to sulphuretted hydrogen, the metal having a strong attraction for sulphur.

The lunar caustic of the surgeon is nitrate of silver, which has been melted, and poured into a cylindrical mould. The salt blackens when exposed to light, more particularly if organic matters of any kind be present; and it communicates a dark stain to the hair, and is employed in "indelible" ink for marking linen. The black stain is thought to be metallic silver; it may possibly be suboxide.

Berthollet's *Fulminating Silver* was precipitated oxide of silver digested in ammonia: it explodes while moist, when rubbed with a hard body; but when dry, the touch of a feather is sufficient. A similar compound containing oxide of gold exists.

It is easy to understand the reason why these bodies are subject to such violent and sudden decomposition by the slightest cause, on the supposition that they contain an oxide of an easily reducible metal and ammonia: the attraction between the two constituents of the substances is very feeble, while that between the oxygen of the one and the hydrogen of the other is very powerful. The explosion is caused by the sudden evolution of nitrogen gas and vapour of water, the metal being set free.—*Fownes's Manual.*

Silver is admirable for culinary and other economical uses, not being attacked in the slightest degree by any of the substances used for food. It is necessary, however, in these cases to diminish the softness of the metal by a small addition of copper. The standard silver of England contains 222 parts of silver and eighteen parts copper.

In the time of William the Conqueror, the English pound was a pound weight of silver, coined into twenty shillings; now a pound is worth less than four ounces of silver, and the pound is coined into sixty-six shillings. Here is the scale of reductions taken from Lord Liverpool's Treatise on Coin:

	s.	*d.*
28th Edward I., a pound-weight of silver was coined into	20	3
18th Edward III.	22	0
20th Edward III.	22	6
27th Edward III.	25	0
13th Henry IV.	30	0
4th Edward IV.	37	6
18th Henry VIII.	45	0
2d Elizabeth	60	0
43d Elizabeth	60	0
56th George III.	66	0

Jonathan Duncan, B.A., on the Currency, 1857.

The new art of Photography is founded on a knowledge of the properties of four chemical compounds of silver, viz. on the change produced by the influence of light on chloride and iodide of silver; on the reconversion of the altered silver compound into metallic silver by means of pyrogallic acid or some other reducing agent; on the solubility of silver compounds in water containing sea-salt or hyposulphite of soda; and finally, on the solubility of collodion in alcohol.

FINE DIFFUSION OF GOLD.

Professor Faraday supposes that if a leaf of gold, which is only $\frac{1}{280000}$ of an inch thick, and weighs about 0·2 of a grain, yet covers a superficies of nearly ten square inches, were diffused through a column of solution having that base, and 2·7 inches in height, it would give a ruby fluid equal in depth of tint to a good red rose; the volume of gold present being about the one five hundred thousandth part of the volume of the fluid.

HARDNESS OF METALS.

Messrs. Calvert and Johnson have made a series of experiments with pretty large masses of metal to test their comparative hardness; and the following is a most useful table which has been prepared, embracing the results of their investigations:—

Names of Metals.	Hardness.
Cast Iron	1·000
Steel	——
Wrought Iron	·948
Platinum	·375
Pure Copper	·301
Aluminium	·271
Silver	·208
Zinc	·183
Gold	·167
Cadmium	·108
Bismuth	·52
Tin	·27
Lead	·10

This table exhibits the remarkable fact that cast iron is harder than all the other metals; it was found to be harder than any alloy.

It is well known to chemists that cast iron, and one or two other metals, in the act of solidifying enlarge, so as to fill out sharply the minute parts of the mould, which is, indeed, the property on which their great use chiefly depends.

GOLD TESTS.

Mr. Tennant, the practical mineralogist, states the specific gravity of gold, tried by four different tests, to be, 15, 15·7, 16·5, 17; so that, as a mean, the specific gravity of gold is sixteen times greater than water; while that of copper pyrites is 4·5; iron pyrites, 4·3; mica, 3. The blowpipe is a most useful and simple instrument in these operations: it can be used with a penny candle and a halfpenny-worth of charcoal; so that for eightpence or tenpence a primitive furnace can be purchased. Gold may be cut with a knife like lead, and bent and beat out in thin leaves. Iron pyrites cannot be cut, or even scratched with a knife; copper pyrites can; and both are brittle. Mica is foliated and elastic. When the blowpipe is applied to gold, it retains its colour; while copper and iron pyrites lose theirs, and the latter become magnetic. Gold is also not acted upon by nitric, muriatic, or sulphuric acid singly: brass filings are readily acted upon by nitric acid. A mixture of nitric and muriatic acids dissolves gold, and is therefore named *Aqua Regia*, gold being the king of metals.

SCIENTIFIC GOLD-SMELTING.

It is not the precious character of a metal in a mine that renders it important, but its relative amount, making the difference between profit and loss in obtaining it. Mines which have been abandoned for centuries on account of their poverty, though known to be auriferous, have often been rendered profitable in working by an application of science. The gold-mines of Reichenstein in Silesia had been abandoned for five centuries, when the process of Professor Plattner was adopted. The ores of the mines are arsenical pyrites, containing about 200 grains of gold in the ton. These are roasted in a reverberatory furnace, surmounted by a large condensing chamber, on which the arsenic is deposited as it rises in fumes. Oxide of iron, a certain quantity of arsenic, and the gold in the ore, remain beneath. These are placed in a vessel, so that a current of chlorine gas is transmitted through them. The gold and iron are attacked, are separated from the residue by solution in water, and the gold is precipitated by sulphuretted hydrogen. The importance of this process is evident; and it is but justice to Dr. Percy to state that in 1848 he advocated the employment of chlorine for a similar purpose.

In Hungary, from a depth of 200 fathoms, the gold matrix is raised, and so skilfully manipulated as to work at a profit, although only producing one-tenth of an ounce of gold from a ton of the matrix.

METALLIC MANGANESE.

The great hardness of this metal fits it for mechanical use: it turns the edge of the best-tempered files, and, set at a sharp angle, it can be advantageously substituted for the diamond in cutting glass, and even in the polishing of steel and other metals. It is so susceptible of polish as to appear applicable for the purposes of optical instruments—for instance, the mirrors of telescopes; and plates of it have been kept for two months in the atmosphere of a laboratory, charged throughout with moisture and other vapours, without the polish having suffered. Although it cannot be forged, it can be rolled into shapes. Its alloys are capable of yielding useful substances. It is an established fact, that all steel contains small portions of manganese. It has long been considered indispensable to add substances which contain this metal to the powder used for cementation in making steel. The valuable variety of steel known as *Wootz* perhaps owes its properties to the *addition* of manganese.

DISCOVERY OF CHLORINE.

At the close of the last century, the Swedish chemist Scheele made a series of experiments on the black oxide of manganese. To some this might have seemed an unprofitable waste of time; but what was the result? Chlorine was discovered, a substance of the greatest importance in the arts. Berthollet, finding that this gas changed the colour of the corks of the bottles in which it was confined, suggested its employment as a bleaching agent. This led to a total revolution in the art of bleaching, shortening the process from several months to a few hours.

By far the most eligible method of employing the bleaching agencies of chlorine consists in combining it with lime ("bleaching powder"), as follows: Gaseous chlorine, being liberated from a mixture of salt, sulphuric acid, and black oxide of manganese, is caused to pass over and among large bulks of slacked lime, which, being continually moved about by rakes, the full absorption of chlorine is obtained. Chlorine is, however, devoid of bleaching power except it be in the presence of water. The *rationale* of this requires to be explained. Chlorine, by action on water, decomposes the latter, giving rise to the formation of hydrochloric acid, and the liberation of oxygen. Most probably the ultimate bleaching effect is due to the *oxygen* thus liberated.—*Brande's Lectures,* by Scoffern.

RESTORATION OF ANCIENT BRONZES.

M. Chevreul selected, from among certain ancient bronze statuettes brought from Egypt, a small completely oxidated figure of Anubis, and placing it in a porcelain tube, he filled the tube with hydrogen gas, and raised it to a dull red heat. Presently, water of a green colour was seen to condense in the bell-glass; and after letting the apparatus cool, "I took out the statuette," says Chevreul, "completely revivified. I placed it before the French Academy, together with the water and chlorhydric acid, which represented the oxygen and chlorine of Egypt transformed at Paris by hydrogen into water and acid."

THE ANCIENT EGYPTIANS' WORKING METALS.

The skill of the Egyptians in metallurgy was very great: we have ample proof of the working of metals at the earliest times of which any monuments remain; nor is it too much to say that some of the secrets they possessed, particularly in the manufacture of bronze, are still imperfectly known to us.

In connection with this art, the paintings notice the forceps, the blowpipe, and the bellows, which last even appear to show an acquaintance with the principle of the valve; and though they give very few of the inventions of Egypt, they prove the early use of the syphons, and many efficient tools of different crafts. The syringe was also known; and one instrument occurs, even on the monuments of the fourth dynasty, which has the appearance of a hand-pump. And if many of their arts, as well as their skill in mensuration, geometry, arithmetic, astronomy, and various branches of science, are unnoticed, we are not surprised at the omission of subjects so little suited to sculpture, or the embellishment of a tomb.

Surgical instruments have been found; and in the tombs other instruments, chiefly bronze; among which are small bells, but it is uncertain to what period they belong, or when bells were first invented. There are likewise knives of various forms; one of them, now in the Louvre collection, is 12 inches long. Bronze needles were not uncommon; and a pair of bronze tongs found at Thebes, and now in the British Museum, are remarkable for their finish, and for the very Egyptian caprice of making their two ends in the form of fish.

Though gold-beating in its modern advantageous state is an improvement of the seventeenth and eighteenth centuries, the Egyptians overlaid wood and other materials with leaf of great fineness at a very remote age; and beating, damascening, engraving, casting, inlaying, wire-drawing, and other processes, were adopted by them more than 3000 years ago. It is not, therefore, surprising that Homer should mention the horns of an ox overlaid with gold, as well as other arts long known in Egypt. But the covering of gold was generally of considerable thickness compared to what we use at the present day.

Gold was the precious metal *par excellence*, and is shown to have been used in Egypt at an earlier time than silver, this last being called "white gold," or "*noub-hat*," whence *hat*, "white," alone came to signify "silver." The Egyptians had no coined money: their gold and silver was in rings, similar to those used in the present day at Sennaar; and, like the iron rings of the ancient Britons mentioned by Cæsar, when purchases were made, they were tried in the scales to ascertain if the "money" was "in full weight."

The use of other metals, as tin and zinc (mostly for bronze and brass), as well as iron and steel, is either directly proved by discoveries in the tombs, or inferred from the monuments: and the manufacture of bronze is shown to have dated at least as early as the fifth dynasty, more than 4000 years before our era. The bronze of Egypt varied in its quality according to the alloys it contained, some having more or less tin, some being mixed with silver or other metals; but that for ordinary purposes contained 80 or 90 of copper to 20 or 10 of tin, like most bronze of Roman times. The fine quality of Egyptian metal mirrors and other ornamental objects is well known.

THE INVENTOR OF AMALGAMATION.

In the year 1640, there was written a work on metallurgy, and the use of quicksilver in refining gold and silver, by Alonzo Barbara, a minister of the church of St. Bernard at Potosi. He discovered the process of amalgamation by mere accident; for being desirous of fixing quicksilver, he mixed it with finely-powdered silver-ore, and soon found that the mercury had attracted every part of silver to itself, which presented him with the idea of refining metals by means of mercury. This experiment he made in 1600; but he was probably unacquainted at the time with the existence of smelting-works in America, and does not appear desirous of claiming the invention of amalgamation as practised in that country. The book, though published at that late period of the art, and notwithstanding there were many superior treatises on the same subject already published in German, was considered of such importance by the Spaniards, as containing all their metallurgic secrets, that they endeavoured to suppress it; but a portion of it was translated into English in 1674.

The late Mr. Children, F.R.S., discovered a method for extracting silver from its ore without amalgamation, and derived considerable profit by selling the right to use it to several South American mining companies, in the year 1824.

THE MANUFACTURE OF IRON.

Of all the metals, Iron is the most widely diffused, the most abundant, and the most useful. Hence the processes of its application are the most numerous; and their history carries us back to the remotest ages. It has been shown, by reference to the four books of the Mosaic law, that Iron was known and used in the earliest ages of the world. In Deuteronomy it is cited as the essential and last fruit of the promised land. From various passages in Hesiod, Homer, and Æschylus, it is rendered probable that the ancient Greeks, though acquainted with both iron and bronze, used the latter in the construction of their warlike weapons till the period of the Heroic ages; but that after that time bronze was superseded by iron obtained from the Chalybes; and from passages from the writings of Polybius, Pliny, and Diodorus, the conclusion is drawn that even in the earliest times the Romans used weapons of iron which they obtained principally from Spain. Mr. Arthur Aikin mentions as a curious fact, that cutting and even surgeons' instruments were found in the excavations at Herculaneum and Pompeii made of *bronze*, though some were also found of iron; from which it is to be concluded, that at this period (about the year 59) the great superiority of iron over every other kind of metal in the manufacture of cutlery was only partially acknowledged.

Sir Gardner Wilkinson informs us that Iron was known in Egypt at a very remote period; and the butchers sharpening their knives on a bar, which, from its blue colour, was evidently steel, is represented on monuments of the fourth dynasty, as well as on those of later time. The case-hardening of iron, by plunging it red-hot into water, is even mentioned by Homer; and the more we inquire into and become acquainted with the customs of people in the early ages of the world, the more we are convinced that iron supplied their simplest wants much in the same way at all times, and that many secrets were known which we blindly suppose to be of late date. If Tubal Cain was, ages before the time of Moses, "an instructor of every artificer in brass and *iron*," the discovery of these will not date at a very recent period. Nor is it sufficient to establish the fact of an acquaintance with the use of iron: it is evident that its properties as steel were not unknown; and those who deny a nearer approach to it than case-hardening will find it difficult to reconcile the mention of "a bow of steel" (Ps. xviii. 34), and other evidence of its use, with the mere hardening of the external surface of iron.

Dr. Livingstone, in his recent researches in South Africa, found on the river Lucaïla the strong massive ruins of an iron-foundry, erected in the year 1768, and by the order of the famous Marquis of Pombal. The whole of the buildings were constructed of stone, cemented with oil and lime. The dam for water-power was made of the same materials, and 27 feet high. This had been broken through by a flood, and solid blocks many yards in length were carried down the stream, affording an instructive examplo of the transporting power of water. There was nothing in the appearance of the place to indicate unhealthiness; but eight Spanish and Swedish workmen being brougnt hither for the purpose of instructing the natives in the art of smelting iron, soon fell victims to disease and "irregularities." The effort of the Marquis to improve the mode of manufacturing iron was thus rendered abortive. Labour and subsistence are, however, so very cheap, that almost any amount of work can be executed at a cost that renders expensive establishments unnecessary. A party of native miners and smiths is still kept in the employment of the Government, who, working the rich black, magnetic iron-ore, produce for the authorities from 480 to 50 bars of good malleable iron every month. They are supported by th appropriation of a few thousands of a small fresh-water fish, calle "caeush," a portion of the tax levied upon the fishermen of the Coanza —*Dr. Livingstone's Missionary Travels.*

The art of smelting iron was known in England during th time of the Roman occupation; and in many ancient beds of cin ders, the refuse of iron-works, Roman coins have been found.*

The working of steel was also practised in Britain before th Norman conquest; and we are told that not only was the arm of Harold well supplied with weapons and defensive armou of steel, but that every officer of rank maintained a smith, wh constantly attended his master to the wars, and took charge o his arms and armour, to keep them in proper repair.

The principal ancient seats of the iron manufacture in thi country appear to have been in Sussex, and the Forest of Dean, or Arden, as it was then called. It is known that iron-work existed in that part of Gloucestershire in 1238, because there exists among the patent rolls of Henry III. of that date one entitled "De Forgeis levandis in foresta de Dean." Remain of ancient iron-furnaces have also been found in Lancashire, Staffordshire, and Yorkshire.

In South Wales, a charcoal furnace and forge were commenced at Pontypool in the 16th century (about 1505), so that this is one of the earliest seats of the iron-trade; but there is reason to believe that the Romans worked iron-ore in these hills, as they undoubtedly did in Dean Forest, ancient heaps of slag being occasionally struck upon. The early furnaces consumed so much timber for fuel, that in the reign of Elizabeth acts were passed prohibiting the erection of iron-works, except in districts specified. Many years elapsed before coal could be successfully applied to the smelting of iron; but in 1740, after nearly a century and a half had been wasted, this great result was obtained at the Coalbrooke iron-works in Shropshire. In that year Monmouthshire only contained two furnaces, the make of which was 900 tons annually; and so slowly did the trade progress, that in 1788 only one more furnace had been put up; but the aggregate make of the county had increased to 2100 tons, owing to the use of the steam-engine. The Nantyglo works, now almost the greatest in the world, were commenced in 1795. The iron-works in the Monmouthshire hills now extend about twenty miles; and mineral property here has risen from 5*s.* an acre surface-rent to 1500*l.*, or more, underground. In the vale of Taff, before the 17th century, rude attempts were made to smelt iron-ore; the bellows was worked by a water-wheel, and charcoal used instead of coke. Merthyr, the "iron capital" of the district, is scarcely a century old. Here, at the Cyfarthfa works, are employed upwards of 4000 men, including colliers; and the strata of coal lie parallel with veins of argillaceous iron-ore. This is the great seat of the bar-iron manufacture for railways.

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* Iron is described by Cæsar as being so rare in Britain, that pieces of it were employed as a medium of exchange; but a century later it had become exceedingly common, since in Strabo's time it was an article of exportation.

The chief iron-works of Sussex were in the Wealden strata, whence the iron-ore was extracted from the argillaceous beds, and was smelted with charcoal made from the abundance of wood. At Buxted, near Lindfield, iron ordnance were made three centuries since.* Up to 1720, Sussex was the principal seat of the iron manufacture in England: the last furnace, at Ashburnham, was blown out in 1827. Kent was alike noted for its iron; and the last great work of its furnaces was the noble balustrades and gates which surround St. Paul's Cathedral, London: they were cast at Gloucester furnace, Lamberhurst, and cost upwards of 11,202*l.* "In the middle ages, and down even to a late date, while Dudley and Wolverhampton were obscure names, the forges of Kent and Sussex were all a-glow with smelting and hammering the iron which the soil still yields, although it is not worth the while of any one to work it. The discovery of the coal-fields of Wales and Staffordshire gave the Kent and Sussex furnaces their death-blow, leaving the country dotted with forge and furnace farms, and deep holes, now filled with tangled underwood, from which the ore was brought." (*Saturday Review*, No. 182.) Kent and Sussex have no coal, and the iron manufacture left these counties when smelting with coal or coke began to supersede smelting with charcoal.

Iron was also worked in Surrey. John Evelyn, in a letter to John Aubrey, dated February 8, 1675, states, that on the stream which winds through the valley of Wotton "were set up the first brass mills, for casting, hammering into plates, and cutting and drawing into wire, that were in England; also a fulling mill, and a mill for *hammering iron*, all of which are now demolished. Such a variety of mills on so narrow a brook, and so little a compass, at that time was not to be met with in any other part of England." The last of these mills gave its name to a small street or hamlet in the parish of Abinger, which to this day is called *the Hammer.*

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* Iron ordnance were first cast in 1543, at Buxted in Sussex, by Ralph Hogge, assisted by Peter Bawde, a Frenchman, and his covenanted servant John Johnson; and the memory of whose works, of which two specimens are still existing in the Tower of London, is preserved in

"Master Hogge, and his man John,
They did cast the first can-non."

—*W. D. Cooper, F.S.A., Archæologia*, vol. xxxvii. p. 483.

The principal operations of the iron manufacture have been thus briefly described by Mr. Noad : There are upwards of forty different ores of iron, the metal occurring in all rocks. The amount of carbonate of iron in the coal-measure iron-stones varies from 50 to 80 per cent. There are two distinct qualities, pig-iron and malleable or bar-iron, the second being the result of an extension of the processes necessary for the production of the first kind, pig-iron. The first process is the Blasting. The blast-furnace is composed of stone or brick, within which is a casing of masonry about fourteen inches thick ; next comes a space of about six inches filled with river sand, compactly rammed in, which, being a bad conductor of heat, tends to preserve the casing of masonry ; lastly, is a coating of best fire-brick about fourteen inches in thickness. The furnace when in full work contains upwards of one hundred tons of materials, to supply the requisite heat for which a powerful and constant blast of air is sent in at three or four different sides through tubes surrounded with a stream of cold water, and which tubes are called "Tuyeres." Some of the large Welsh furnaces consume upwards of 20,000 gallons of air per minute, a quantity exceeding in weight the totals of all the solid materials used in smelting. The blast enters the furnace under a pressure of from two to three pounds and a half to the square inch, the air being heated to about 600° before it enters the furnace, by which an effective increase of about one-eighth, or of 360° Fahr., is obtained.

This improvement has in many cases enabled manufacturers to increase their weekly production of iron 50 per cent, and to produce a better sort of cast iron from inferior materials. It has effected a great saving of fuel ; and it has enabled the Scotch iron-masters to smelt alone and with coal the *black-band* iron-stone, discovered by Mr. Mushet in 1801. The colour, consistence, and general appearance of the cinders, or slag, indicate the working of the furnace. They are received from the furnace in large iron boxes, whence, as soon as they have solidified, they are removed on railways, to be used for the construction of roads, rough walls, &c. The iron from the blast-furnace is usually "tapped" twice in twenty-four hours ; the liquid metal is either received into moulds, where it assumes the form of semi-cylindrical bars, technically called "pigs," or it is run into wider channels, from which, after being broken up, it is removed directly to the "refinery." The cinders alluded to above are not the cinders of the blast-furnace, but forge cinders, that separate from the cast iron during the processes of refining, puddling, and balling, by which the cast iron is converted into wrought iron. These cinders are very rich in iron, and are calcined to rid them of sulphur, which would make the metal "hot short," so that it could not be worked under the hammer. The forge cinders also contain phosphorus, which cannot be separated, and makes the iron "cold short," so that it breaks on attempting to bend it. Lastly, the gases from the furnace are economically applied: of the heat produced by the combustion of the fuel in a coal-fed blast-furnace, only 18·5 per cent was originally realised in carrying out the processes of the furnace, the remainder 81·5 per cent being lost. This loss is no longer permitted. The gases are now collected at the mouth of the furnaces, and conveyed by large pipes underneath the boilers of the engines and round the hot-air stoves. The principle has been carried out in great perfection at Cwm Celyn: the pipes are six feet in diameter, and are lined with fire-brick; and the gases from *two* furnaces only more than suffice for the supply of seven boilers, and for the hot blast for both furnaces, at a saving of full 10,000 tons of coal a year.

Foremost among the great improvers of the iron manufacture ranks Henry Cort, who, in 1783-4, introduced the flame of pit-coal in the puddling furnace, and the passing of wrought iron through grooved rollers instead of forging under the hammer; yet the inventor of these valuable improvements, and his descendants, have been deprived of their just reward.

Although in England the use of iron as a building material is comparatively modern, M. Gutzlaff has proved that the art of constructing buildings of cast iron has been known for centuries in China. He discovered there a pagoda entirely built of cast iron, and covered with bas-reliefs and inscriptions, which in their forms, characters, and dates, show that they are as old as the dynasty of Tang, which was upon the throne from the fifth to the tenth century of the Christian era. The pagoda has seven stories, each containing curious historical pictures; it is strikingly elegant in form, and in this respect surpasses every thing hitherto seen by M. Gutzlaff in China.

Mr. Rennie first largely employed iron as a building material, s voussoirs (wedges), in the Southwark Bridge. Vast roofs re now constructed of iron; and lighthouses, churches, factories, and storehouses, are manufactured in England, then taken to pieces, to be reërected in all parts of the world. The trength of this metal in building is enormous, since iron with -40th part of the substance of stone will give equal strength f support.

THE MANUFACTURE OF STEEL.

The existing and generally-received theory of the formation nd the alleged actual composition of Steel is, that it is produced y the addition to pure iron of some apparently insignificant roportion of carbon. This simple combination is, and ever has been alleged to be, the sole cause of *the conversion* of iron into Steel. This magical effect, which is a kind of chemical anomaly, has been disputed by Mr. C. Binks, who, from a practical investigation of considerable length and detail, adduces evidence proving:

> That the substances whose application to pure iron convert it into Steel all contain nitrogen and carbon, or nitrogen has access to the iron during the operation.
>
> That carbon alone, added or applied to pure iron, does not convert it into Steel.
>
> That nitrogen alone, so added or applied, does not produce Steel; but that it is essential that both nitrogen and carbon should be present, and that no case can be adduced of conversion in which both these elements are not present and in contact with the iron.
>
> That nitrogen as well as carbon exists substantially in Steel after its conversion; and such presence is the real cause of the distinctively physical properties of steel and of iron, in which latter those elements do not exist.
>
> That presumptively, but not demonstratively, the form of combination is that of a triple alloy of iron, carbon, and nitrogen; but it remains to be determined as to the relative proportion of elements when their union gives pure Steel.

Mr. Binks then proceeds to show there to be nothing in the chemical history of nitrogen that is incompatible with its substantial existence in Steel.

> In the presence of our atmosphere, with its affluence in nitrogen, why should we ever ascribe to that element some merely negative attributes, or properties serving only to control or modify the more vivid action of some other element? . . . . An element existing every where, touching every thing, penetrating, permeating, and by diffusion intermingling itself with, every gaseous body it comes in contact with, might be supposed, *à priori*, to exercise other functions (and many) besides the merely negative ones usually assigned to it. And, among speculations that naturally arise out of these questions, is it quite impossible that the play of colours peculiar to heated steel—the assumption, for example, of the pure blue and the purple—may not in reality be due to some phase of development of some of the forms of ferrocyanide of iron?
>
> We possess further evidence of the use of nitrogen from another and unexpected quarter. It is on record, as a practice of the Indian *Wootz*-Steel maker, that along with his iron or imperfect Steel, in his melting-crucible, he places, as his carbon-giving material, the wood of the *Cassia auriculata*, and covers the whole with the leaves of the *Convolvulus laurifolia*, both vegetable productions rich in azotised matters. These, placed in his closest crucible, will give an azotised carbon in contact with the metal. And what may have been the origin of this far-back practice of the East—this to us apparently the empirical handicraft of some Indian artificer? Has it originally been the fruition of some mere accident, or of some induction or deduction? or is it a relic of some state of civilisation and of science superior to those of the West? The Sheffield artisan seeks, even up to the present day, that which the Indian artificer had found out ages ago.

Mr. Faraday has made a series of investigations with the object of ascertaining what metals could be advantageously employed as alloys of Steel, in order to improve its hardness and temper. Among the important practical results of this research, we may notice the fact that the addition of a small quantity of silver (1 part in 500) produces a steel decidedly superior in quality to the best previously manufactured.

STEEL PRODUCED BY GALVANIC ACTION IN THE EARTH.

The late Mr. Weiss, to whose inventions modern surgery is under considerable obligations, remarked that Steel seemed to be much improved when it had become rusty in the earth, and provided the rust was not factitiously produced by the application of acids. He accordingly buried some razor-blades for nearly three years, and the result fully corresponded to his expectation. The blades were coated with rust, which had the appearance of having exuded from within, but were not eroded, and the quality of the steel was decidedly improved. Analogy led to the conclusion that the same might hold good with respect to iron under similar circumstances: so, with perfect confidence in the soundness of his views, he purchased, as soon as opportunity offered, all the iron, amounting to fifteen tons, with which the piles of old London Bridge had been shod. Each shoe consisted of a small inverted pyramid, with four straps rising from the four sides of its base, which embraced and were nailed to the pile; the total length, from the point which entered the ground to the end of the strap, being about sixteen inches, and the weight about eight pounds. The pyramidal extremities of the shoes were not found to be much corroded, nor, indeed, were the straps; but the latter had become extremely and beautifully sonorous. When manufactured, the solid points in question were convertible only into very inferior steel; the same held good with respect to such bolts and other parts of the iron-work as were subjected to the experiment, *except the straps;* these straps, in addition to the sonorousness, possessed a degree of toughness quite unapproached by common iron; they were, in fact, imperfect carburets, and produced steel of a quality infinitely superior to any which Mr. Weiss had ever met with; insomuch that while it was in geneal request among the workmen for tools, they demanded higher wages for working it. The straps were consequently eparated from the solid points, which last were sold as old iron. The exterior difference between the parts of the same shoe led t first to the supposition that they were composed of two orts of iron; but, besides the utter improbability of this, the ontrary was proved by an examination, which led to the inerence that the extremities of the piles having been charred, the straps of iron, closely wedged between them and the stratum in which they were imbedded, must have been subjected to a galvanic action, which, in the course of upwards of six hundred years,* gradually produced the effects recorded.

DISCOVERY OF SCARLET DYE.

A scarlet colour resulting from the treatment of a decoction of cochineal with a chloride of tin (and tartar), is a very celebrated dye, and has a curious history. It appears that the Dutch chemist Drebbel, resident at Alkmaar, had prepared some decoctions of cochineal for filling a thermometer-tube. The preparation was effected in a tin vessel; and into this some *aqua regia* (nitro-muriatic acid) having been spilled by accident, a rich scarlet colour was observed. Thus, by mere chance, was the discovery made that oxide of tin in solution yielded, by combination with the colouring matter of cochineal, a scarlet dye. Drebbel communicated his discovery to Kuffelar, an ingenious dyer of Leyden, who was the first to carry out its manufacture: hence it was called *Kuffelar's Colour*. The process soon reached Van der Gecht and Gulich, who, however, appear to have discovered the process by their own independent investigations. Van der Gecht, in 1550, communicated the secret to the Gobelins, the celebrated tapestry manufacturers. Nearly a century after this, in 1643, one Kepler, who had acquired a knowledge of the process in Flanders (his native country), came over to England, and settled at Bow; where, having practised the dyeing of this colour, it went by the name of *Bow Dye*. Kepler, however, did not carry this process to such perfection as the brothers Gobelin, or, indeed, the dyers of Flanders; nor was the art of scarlet dyeing thoroughly known in England until one Bauer, or Brewer, having been invited to England in 1667 by Charles II., with the promise of a large salary, practised the art in his own manufactory.†—*Brande's Lectures.*

ARTIFICIAL ULTRAMARINE.

Of all the achievements of inorganic chemistry, the artificial formation of Lapis Lazuli was the most brilliant and the most conclusive. This mineral is of a beautiful azure blue colour, remains unchanged by exposure to air or to fire, and furnishes us with the most valuable pigment Ultramarine.

Ultramarine was dearer than gold. It seemed impossible to form it; for analysis had sought in vain the colouring ingredient. It was shown to be composed of silica, alumina, and soda, three colourless bodies; with sulphur and a trace of iron, neither of which are blue; and no other body had been detected in it to which its colour could be ascribed. Yet now, simply by combining in the proper proportions, as determined by analysis, silica, alumina, soda, iron, and sulphur, thousands of pounds weight are manufactured from these ingredients; and this artificial Ultramarine is even more beautiful than the natural, while for the price of a single ounce of the latter we may obtain many pounds of the former.

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* The building of London Bridge was commenced, and most probably the piles were driven, in 1176: the Bridge was removed in 1832; so that it stood 656 years.

† Fearne, the eminent lawyer, who was profoundly versed in medicine and chemistry, obtained a patent for dyeing scarlet.

With the production of artificial Lapis Lazuli, the formation of mineral bodies by *synthesis* ceases to be a scientific problem to the chemist.—*Liebig.*

SIR HUMPHRY DAVY'S ELECTRO-CHEMICAL THEORY OF VOLCANOES.

Potassium is a soft, silver-like metal that melts at 136°, can be distilled at a low red-heat, and kindles in the air at the temperature where it begins to vaporise. In the dry air it quickly combines with oxygen, and is soon covered with a white rust. This is potassa. Potassa attracts the aqueous vapour of the atmosphere, and becomes potash, which draws down more and more moisture, till the original bright bead has become a little pool of alkali dissolved in water. This solution combines rapidly with the carbonic acid of the air; and if it be subsequently boiled to dryness, there is left the carbonate of soda—the pearl-ash of the housewife.

Potassium is lighter than water. It breaks into flame the moment it touches water or ice. If plunged under water, there is no combustion; but hydrogen is discharged with turbulence and resistlessness. These remarkable but far from anomalous properties suggested to Sir Humphry Davy the conjecture that the solid body of the world is composed of potassium and the metals that resemble it; and that volcanic eruptions are produced by the occasional incursion of the waters of the deep, or of the great mountain tanks, in the still domain of these Atlantic metals. The far greater part of the investigated crust of the earth is certainly composed of such oxidated metals, and the specific gravity of the whole globe is supposed to be less than that of even the rocks; so that it is at least possible that there may be more of sound prediction in this sublime conception than the majority are inclined to think.—*North British Review*, No. 3.

It should be added that Davy in the most distinct manner gave up this opinion; but he still asserted that the presence of oxidisable metalloids in the interior of the earth might be a *coöperating* cause in volcanic processes already commenced.

THE NEW METAL ALUMINUM.

This is the metallic base of the earth Alumina, which is composed of oxygen and the metal Aluminium. Sir H. Davy was led to believe alumina to be a metallic oxide; but it was Wöhler who first separated the metallic substance by decomposing the chloride of Aluminium by means of potassium or sodium, when the chlorine unites with the metal employed, and leaves the Aluminium free. Till recently it was procured only in very small quantities, and was regarded as a chemical curiosity. However, in 1857, the Rev. Mr. Reade explained to the British Association that he had digested alumina in a solution of iodine, and thus obtained a semi-white metallic substance; attempting to solve the problem which has so extensively occupied the attention of practical chemists in *extracting the pure metal from its compounds.* Upon this Dr. Lee remarked: "Mr. Reade lives upon the great basin of Kimmeridge and Oxford clay, in the Vale of Aylesbury. He is therefore really the owner of a fortune, lying, however, under his feet, but which only requires the aid of the chemist to transform it into pure metal and current specie."

Aluminium forms an essential portion of some of our most brilliant gems, including corundum, the sapphire, the oriental ruby, and the emerald; and we have a boundless supply of aluminous substances in granite, slates, schist, and especially in clays. Still, the extraction of the metal is a labour of great difficulty. Its oxide, alumina, will not surrender its oxygen to any known fuel, at any known temperature. It has been also stated that the metal itself could resist the highest temperature without absorbing oxygen; but we now learn that if the temperature be raised to a welding heat, Aluminium will burn with great intensity, until a stratum of alumina is formed upon its surface sufficiently thick to exclude the atmosphere.

The first access to Aluminium was opened by Oersted, who, by an ingenious concentration of chemical force, converted the oxide into the chloride of Aluminium, the vapour of which Wöhler decomposed by the vapour of potassium, and thus obtained minute quantities of Aluminium. In 1856, M. Deville simplified the process, and improved the manufacture of sodium (the metal which he employs as the reducing agent), thus greatly diminishing the cost; and in the private laboratory of the Emperor of the French, M. Deville next produced a whole bar of Aluminium.

M. Corbelli has, however, extracted Aluminium directly from clay by dissolving it in acid, heating the earthy matters, then mixing them with yellow prussiate of potash and sea-salt, and heating them in a crucible until a white colour (the Aluminium) is produced.

Aluminium is extremely light (one-fourth the weight of silver), is more malleable and ductile than silver, and will neither rust nor tarnish. It is very sonorous, and is an excellent conductor of heat and electricity. It is specially adapted for surgical instruments; and, as it is not corroded by acids, is the best-known metal for culinary vessels. Pianoforte strings have been made of it; and it may be used for musical instruments. Could it be more cheaply produced, it would be much employed for coating iron surfaces, as rails and pipes. Spoons and forks and drinking-cups have been made of it, at about half the cost of silver. With gold Aluminium forms an alloy very closely resembling the precious metal. It is used for brooches and studs, bracelets, pins, and combs, pencil-cases, thimbles, seals, and medallions; for spectacles, as it does not blacken the skin like silver; and for reflectors of gas-burners, since it resists the effects of sulphurous emanations, which silver and brass do not. Aluminium would form an excellent substitute for copper coinage; with iron it forms an alloy of hardness superior to bronze; with copper it dips a fine golden colour in nitric acid. Its alloy with nickel is more fusible and harder than the pure metal. If Aluminium be fused with oxide of lead, a violent detonation ensues, the crucible breaks into pieces, and even the doors of the furnace are driven to a distance.

M. de Lille, of Paris, has obtained from cryolite (a fluoride of Aluminium and of sodium, found only in Greenland) the metal Aluminium at as low a price as silver; and since an ounce of the former has four times the volume of an ounce of the latter, it will of course give articles of plate of the same size at one-fourth the price. Cryolite also yields crystals of soda, and a clay valuable to calico-printers.

Mr. Gerhard has obtained the metal most economically by combining in an oven hydrogen gas with the fluoride of Aluminium, and forming hydrofluoric acid, which is taken up by iron, and thereby converted into fluoride of iron; whilst the resulting Aluminium remains in the metallic state in the bottom of trays containing the fluoride. Dr. M'Adam placed Aluminium medals in a solution of caustic potash, when hydrogen was evolved; the surface of the metal became beautifully frosted, and did not afterwards become tarnished.

ALUM IN BREAD.

Dr. G. Wilson, in his paper on "Chemical Final Causes," shows the unsuitableness of Aluminium to the organism, and the cause of our failure in its detection. Aluminium (he says) forms only a peroxide, alumina; so that it is an unpliant, unaccommodating metal. Alumina, moreover (the dyer's most useful mordant), has so excessive an attraction for organic matter, with which it forms insoluble compounds, that it cannot take an active part in organismal changes. In truth, when taken internally, it is prevented, by this precipitation in an insoluble form along with the first organic substance which it encounters, from entering the blood, except in minute quantity, and it is not retained there. (Lehmann's *Physiol. Chem.*) If, indeed, there is any justice in the statement that bakers are in the habitual practice of adding alum to bread, we must be continually swallowing alumina; yet none is found in our blood.

Liebig considers that when alum is added to bread, the soluble phosphates, which the flour largely contains, are decomposed, the phosphoric acid of the phosphates unites with the alumina of the alum, and thus an insoluble phosphate of alumina is formed, while the beneficial action of the phosphates is consequently lost to the system.

Alum works were introduced into England towards the close of the 16th century, when Thomas Chaloner (afterwards Sir Thomas, and governor of Prince Henry, son of James I.), while travelling in Italy, observed that the natural appearances of the country at Puzzeoli, where the Pope had his alum-works, were similar to those on his estate near Gainsborough in Yorkshire. He therefore induced some of the Pope's workmen to accompany him to England; in order to smuggle them away, he put two or three of the men into casks, and in this manner had them conveyed to a ship which was ready to sail. The enraged Pope (to whom England had been previously indebted for its supply of alum) then visited Chaloner with excommunication; and his curse is to be found in Charlton's *History of Whitby*, word for word the same as that read by Dr. Slop in *Tristram Shandy*. Sterne used often to visit his friend John Hall Stephenson (the Eugenius of his story) at Skelton Castle, near Gainsborough, and there became acquainted with the curse in question, which is familiarly known in the neighbourhood.

COPPER.

This metal occurs in the greatest number of places, and in the largest quantity, in the north of Europe, in England and Wales, in many parts of Asia and Africa, and in South Australia and Chili.

The Greeks were well acquainted with copper as *chalcus*: it was used by them, alloyed with tin, for cutting and warlike instruments before iron was known, or at any rate before it was common. Our name, Copper, is said to be derived from the island of Cyprus, where Tamassus was once famous for its copper-mines, in the early colonisation by the Phœnicians. Copper may be reduced to very thin leaves, as we see in Dutch metal, an alloy of 11 copper and 2 zinc rolled into sheets, chiefly at the brass-works of Hegermühl. It may also be drawn into very thin wire. After iron and platinum, it is the most tenacious metal: a wire $\frac{78}{1000}$ of an inch in diameter supports a weight of 302 pounds without breaking. It is a good conductor of electricity: hence the wires of electric telegraphs are of copper.* It is extremely sonorous,—hence it forms three-fourths of *bell-metal*. *Brass* is copper and one-third zinc; *gun-metal*, 90 copper and 10 tin; *speculum-metal*, copper and a larger proportion of tin; and *bronze*, 91 copper, 2 tin, 6 zinc, and 1 lead; but the brass of the ancients was copper and tin. *Tutenag* was copper, zinc, and a little iron; *Prince Rupert's metal* and *Pinchbeck*, more copper than in brass; *Manheim gold*, 3 copper and 1 zinc; and *Packfong*, or *White Copper of China*, is an alloy of copper, nickel, and zinc, named German Silver, and used for spoons, forks, &c.

In 1660, when the Royal Society conducted their own experiments, and had their own assay-furnace, we find this entry of an experiment by Sir William Persall:

> Take a handful of the powder of Roman vitriol (sulphate of copper); put it into a gallipot, in a pint of water; put in two or three small irons the length of a span, and three or four times a day constantly stir the water and powder, and move not the irons at all, but let them stand constantly in night and day; within the space of three weeks there will be crusted about the irons, as far as they are in the water, a substance purer than copper, which you may take off, and will be malleable.

Such a result would now be shown by a lad as a piece of "parlour magic."

Copper vessels for cooking, if kept clean, are not dangerous, provided whatever is boiled in them (unless of an acid nature, which will always form some dangerous compound) be not allowed to stand to cool in the vessel, but be instantly poured out. Tinning the insides of copper vessels affords protection so long as the tinning remains entire; but if they be silvered by the electro process, they are acted upon by weak acids, lemon-juice, and vinegar, arising from the deposited silver being so porous as to allow the acids to permeate its substance; and the action is most likely assisted by the formation of a galvanic circuit. In such cases copper has been detected.

The most beautiful carbonate of copper is the mineral Malachite of emerald green, extensively used for veneering and inlaid work. Sir Roderick Murchison considers Malachite to be a subterraneous incrustation produced during a succession of ages by copper solutions trickling through the surrounding loose and porous mass to the lowest cavity upon the solid rock at the bottom of one of the shafts of the copper-works of the Ural.

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* In 1853, a piece of Copper, weighing about 123 pounds, was drawn out at Walker's mills, Birmingham, to a length of upwards of four miles, to be laid down as a line of telegraph, without link or weld.

LEAD.

This abundant metal is employed to cover buildings, to form water-pipes (though Vitruvius, the Roman architect, condemned this practice), and to make vessels for economical purposes. Pigs of lead have been dug up in England with dates and inscriptions proving this metal to have been used here in the time of the Romans. This people, as well as the Greeks, proved the quality of their wines by dipping a plate of lead in them: they knew that it rendered harsh wine milder, but not that the metal was poisonous.*

Lead is used in refining the precious metals because, when mixed with them in a great heat, it rises to the surface, combined with all heterogeneous matters. The oxides of lead are used in dyeing and calico-printing, in the manufacture of glass, earthenware, and porcelain. Lead combined with a little arsenic is made into shot, in lofty towers: the liquid metal is let fall like rain from the top of the tower; the drops in their descent become truly globular, and before they reach the end of their fall are hardened by cooling, so that they retain their round shape.

Red-lead is obtained by melting common lead exposed to atmospheric air; white-lead by exposing sheet-lead to acetic acid. Pewter consists of 80 parts tin and 20 lead.

A commission of German chemists have determined, after long research, that snuff wrapped in lead, even when covered with paper, or combined with tin, gradually becomes poisonous by acting upon and taking up the metal.

THE LEAD-TREE.

The common but very pleasing experiment of the Lead-Tree, is greatly dependent on electro-chemical action. When a piece of zinc is suspended in a solution of acetate of lead, the first effect is the decomposition of a portion of the latter, and the deposition of metallic lead upon the surface of the zinc; it is simply a displacement of a metal by a more oxidisable one. The change does not, however, stop here: metallic lead is still deposited in large and beautiful plates upon that first thrown down, until the solution becomes exhausted or the zinc entirely disappears. The first portions of lead form with the zinc a voltaic arrangement of sufficient power to decompose the salt: under the peculiar circumstances in which the latter is placed, the metal is precipitated upon the negative portion, that is, the lead, while the oxygen and acid are taken up by the zinc.—*Fownes's Manual of Chemistry.*

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* Leaden moulded pipes were used in Cardinal Wolsey's time for conveying water 3½ miles from a spring in Surrey, beneath the bed of the Thames, to Hampton Court Palace.

PLUMBAGO, OR "BLACK-LEAD."

Plumbago, erroneously termed "Black-lead," is chiefly composed of carbon with some admixture of other substances, not unfrequently iron. Its importance for the arts and crucibles is well known. After the Borrowdale mines in Cumberland were somewhat exhausted, it became important, for that variety of plumbago employed in art, to obtain some substitute. Several compounds were invented; but nothing succeeded so well as the compressing process patented by Mr. Brockedon, by which much of the Borrowdale Plumbago-dust has been utilised with advantage. It, or any other good plumbago, is ground into fine powder, placed in packets, and then receives a pressure equal to about 5000 tons. To prevent the injurious effects of disseminated air in the packets of fine powder, it is extracted by means of an air-pump; and thus the particles themselves can be brought into close juxtaposition, and forced to cohere.

TIN.

This valuable metal occurs in South America and Malacca, in Saxony and Bohemia, and more especially Cornwall. To this part of our island the Phœnicians came to procure tin and lead, and in return gave salt, earthenware, and copper goods. (*Strabo.*) Hence the western extremity of Britain, with the Scilly Isles, were called the Casseritides, or "Tin-islands," from a root which in some of the Oriental tongues, as well as in the Greek, denotes Tin. The Greeks appear to have known these Tin-works before the time of the Roman conquest of our island. According to Aristotle, the Tin-mines of Cornwall were known and worked in his time: Diodorus Siculus describes them; and the Romans mixed Tin with their copper coins and edge-tools, which are found here.

Tin, dissolved in acids, is much used by dyers for reds and scarlets; and the Purple of Cassius (Tin combined with gold) is employed in enamel-painting and in staining glass. (See "Discovery of Scarlet Dye," p. 118.)

ZINC

Is frequently called in commerce *Spelter*, and was first mentioned by Paracelsus, in the sixteenth century, under the name of *Zinetum*. It is the most combustible metal we have: if beaten out into thin leaves, it will take fire from a common taper. It is much used for roofs in the Low Countries; but in case of fire, the zinc being very combustible, is extremely liable to become inflamed, and, falling around, occasions great danger to those who approach the building. Plates of Zinc are much employed in voltaic batteries. With copper it forms brass. Zinc is much used for coating iron to prevent rusting, and Zinc milk-pans increase the quantity of cream; but if the milk becomes sour while in them, the acid acts upon the Zinc, and forms unpleasant if not poisonous compounds. Zinc in the purely metallic state produces no effect upon the human system, but in combination with oxygen its medical properties are numerous and important.

PLATINUM,

In the language of Peru "little silver," was originally discovered at two places in South America, in New Granada and at Barbacoas. It has been found in considerable quantities in the Ural mountains, and is used for coinage in Russia. It has also been met with in the metamorphic district of the valley of the Drae, department of Isere. It has likewise been found in combination with gold in California; and in 1855 it was estimated that as much as 5300 ounces of Platinum must have been conveyed in this way to the Atlantic States.

Platinum, the heaviest body in nature, is incomparably hard. In the mass it is lustrous white, but may be so finely divided that its particles no longer reflect light, and it forms a powder as black as soot. It will then absorb more than eight hundred times its volume of oxygen gas, and this oxygen must be contained within it in a state of condensation greater than that of liquid water. If a drop of absolute alcohol be let fall upon the Platinum, inflammation will immediately ensue, and the metal will become incandescent.

Dr. Wollaston obtained very fine Platinum wire for the object-glasses of his telescopes, for observing the relative places of the stars, by inserting Platinum wire in a cylinder of silver. wire-drawing the whole, and then melting the silver coating. Now silver wire may be drawn to the three-hundredth of an inch diameter; so that if the Platinum wire was originally one-tenth of the thickness of the silver, it then became only the three-thousandth of an inch. Dr. Wollaston procured some only an eighteen-thousandth, which did not intercept the smallest star. Very fine Platinum wire is also employed as a substitute for hair in making forensic wigs.

It is calculated that a piece of Platinum the size of the tip of a man's finger could be drawn out across Europe.

Platinum is made a fulminate as follows: The triple sulphate of Platinum and ammonia is boiled in a solution of potash; when the sulphuric acid unites to the potash, a portion of the ammonia is evolved, and the remainder, entering into intimate union with the oxide of Platinum, produces fulminating

Platinum. Its explosive powers may be referred to the sudden extrication of nitrogen, ammonia, and aqueous vapour.

Dr. Wollaston, in 1828, transferred a large quantity of Platinum and Palladium to the Council of the Royal Society, to be given "in aid of chemical experiments." A portion of this Platinum has been employed in the construction of a Standard Troy Pound, which is preserved in the Instrument Room of the Royal Society. Dr. Stukely in his Ms. Journal says, under the date of Dec. 13, 1750: "A piece of Platinum was presented to the Society. It is called *Platina del perito*, because of its silvery colour. The Spaniards sell it very dear, and make knife-handles, sword-handles, and many toys of it; it bears a good polish, and is not apt to tarnish. I guess it would be good for speculums to reflecting telescopes."

Dr. Wollaston's name is intimately connected with several chemical discoveries of the highest importance. "In 1804 and 1805, he made known palladium and rhodium,* two new metals contained in the ore of platinum, and associated with osmium and iridium, discovered about the same time by Mr. Tennant. In 1809 he showed that the supposed new metal, tantalum, was identical with columbium, previously discovered by Mr. Hatchett; and shortly before his death he transmitted to the Royal Society a communication, constituting the Bakerian Lecture for 1828, in which he fully describes his ingenious method of rendering Platinum malleable. (*Brande's Manual of Chemistry*, p. 102.) By this invention he is stated to have acquired more than thirty thousand pounds."—*Weld's History of the Royal Society*, vol. ii.

ORIGIN OF CORINTHIAN BRASS.

It was during the mighty conflagration of Corinth, A.U.C. 608, that the celebrated amalgam called Corinthian Brass is said to have been first formed; gold, copper, and silver, having melted and flowed together into one precious mass, which was considered in future ages as more valuable than pure gold. This is, however, thought to be an historic fiction; for another account states the city to have been sacked before it was fired; in which case the Brass may have been a recent discovery of the Corinthian people, and the Romans may have plundered the foundry of its contents.

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* The successful application of rhodium for the nibs of metallic pens, on account of its extreme hardness and durability, was made by the suggestion of Dr. Wollaston.

Poisons.

POISONS OF THE ANCIENTS.

SIR Henry Halford, in one of those delightful papers in which he was wont, as Mr. Pettigrew has gracefully said, to "display the elegant scholar and observant physician," has left us the following curious investigations in the death of celebrated characters of antiquity, with special reference to the knowledge of Poisons possessed by the ancients.

Sylla died in consequence of the rupture of an internal abscess, through an excess of rage; which, according to Valerius Maximus, produced a violent vomiting of blood, and death.

Crassus, the eminent lawyer and friend of Cicero, died of pleurisy; and the course of treatment for this disorder, prescribed by Celsus, and in use at the time,—namely, bleeding, cupping, and blistering,—was so similar to that pursued at the present day, that nothing was probably left undone that could have saved his valuable life.

Pomponius Atticus, whom Cicero loved as a brother, and who was on friendly terms with all parties in the disturbed times in which he lived, was said to have died of a fistula in the loins; it was probably, Sir Henry thinks, a dysentery ending, as that disorder commonly does, in an affection of the lower bowels. He had recourse to starvation, a very common expedient amongst the Romans, and died in ten days, aged seventy-seven

The latter end of Socrates was brought about by the common mode of despatching persons capitally convicted at Athens, namely, by a narcotic poison; but neither Xenophon nor Plutarch tells us the species of poison. The poisons of this class known to the ancients were aconite, white poppy, hyoscyamus, and hemlock. The black poppy might be the Theban drug. The hyoscyamus was used at Constantinople, and was very likely the Nepenthe spoken of by Homer. But most probably the poison administered to Socrates was the same as that given to other condemned criminals, namely, κώνειον, *cicuta*, hemlock. Juvenal attributes his death to hemlock:

> "Dulcique senex vicinus Hymetto,
> Qui partem acceptæ sæva inter vincla cicutæ."

Whatever may have been the species of poison, it was one of weak and slow operation, for the executioner told Socrates that if he entered into earnest dispute, it would prevent its effect; and it was sometimes necessary to repeat the dose three or four times. Its operation was gradually to produce insensibility, coldness of the extremities, and death.

Mr. Petit, in his *Observationes Miscellaneæ*, remarks that the advertisement was not given by the executioner out of humanity, but to save the cicuta; for he was only allowed so much poison per annum! which if he exceeded, he was to furnish the rest at his own expense. This construction is confirmed by the circumstances as related in Plutarch nearly as follows. When Phocion and his four colleagues, condemned for treason at Athens, were led out to have the customary dose of poison administered, and all had drunk except Phocion, no more hemlock was left; upon which the gaoler said he could not prepare any more unless twelve drachmæ of money were given him to buy the material. Some hesitation took place, until Phocion asked one of his friends to supply the money, sarcastically remarking, that it was hard if a man could not even die *gratis* at Athens.

What was that poison by which Hannibal destroyed himself? It is improbable that we shall ever know. Modern chemistry has discovered a variety of subtle poisons that may be introduced into a ring, and, under certain circumstances, destroy life. One drop of Prussic acid may produce paralysis, and, if taken into the stomach, may instantly arrest the current of life. But it was not likely that the Carthaginians were acquainted with Prussic acid; Lybia most probably produced poisons sufficiently subtle and destructive to accomplish the fatal purpose of Hannibal. The report of its being bullock's blood must be a fable, as well as in the case of the death of Themistocles, for it is well ascertained that the blood of that animal was not poison. An accomplished nobleman told Sir H. Halford that he had been present at a bull-fight in Spain, when, after the matador had killed the bull, a person ran up, caught the animal's blood in a goblet, and drank it off, as a popular remedy for consumption.

[Hannibal carried poison in his sword, to despatch himself if he should happen to be surprised in any great extremity; but the sword would have done the feat much better and more soldier-like. And it was below the honour of so great a commander to go out of the world like a rat.—*Butler.*]

With respect to the poison with which Nero destroyed Britannicus, comparing the account given by Tacitus with the effects of laurel-water, Sir Henry was disposed to think that this was the identical drug. It appeared that the Emperor applied to Locusta, a female poisoner, to procure some vegetable poison that would kill speedily. She produced one which destroyed a goat in five hours. Nero, however, required a poison which would kill instantly, and she procured such an ingredient. At the banquet, Britannicus called for water, which the *pregustator* tasted; it was not sufficiently cool; part was then poured off, and the fatal liquid added; the young man drank, was seized with an epileptic fit, and expired. The case is analogous in the effects with that of Sir Theodosius Boughton, who was poisoned by Donellan with laurel-water, and fell down in an epilepsy. In the case of Britannicus, Nero told the company that the young man was liable to such fits; and in the other case, Donellan said that Sir Theodosius had been subject to fits from his infancy. Tacitus mentions a blackness which came over the body of Britannicus; and Sir Henry stated that he was present when the corpse of Sir Theodosius Boughton was disinterred, and its colour resembled that of a pickled walnut. If we could suppose that the Romans were acquainted with the deleterious property of laurel-water, and with the process of distillation, there could be no difficulty in concluding that Britannicus was poisoned with laurel-water. It is true the species of *laurus* which yielded the deleterious liquid did not grow in Italy; but it was a native of Colchis, from whence it might have been brought. The *laurus nobilis* (daphne) grew about Rome, and was used in producing the inspirations of the prophetic priestesses. As to the knowledge possessed by the Romans of the art of distillation, they had not, indeed, a still and refrigeratory like the moderns; but they received the vapour from the boiling herbs in a handful of sponge, which, though a rude, was not an inefficient substitute.

Alexander the Great is said to have been poisoned; but this is inconsistent with the very detailed account of his illness given by Arrian. The report was, that the poison was sent by Antiphon, and was of such a peculiar nature that no silver or metallic substance would contain it; and it was conveyed in the hoof of a mule. But the article was really onyx, as Horace says: now the word *onyx*, in Greek, signifies not only a stone, but *unguis*, a hoof or nail; and the second sense has been evidently given instead of that of a precious stone. Alexander really died of a remittent fever caught at Babylon. As to the cause of it, Arrian expressly states that the king was temperate and forbearing in the pleasures of the table; and when we consider the laborious occupations of Alexander, amidst frost and snow, and especially the marsh miasmata of the Babylonian lakes, Sir Henry thought there was no difficulty in conceiving that this was too much even for his frame of adamant. The diary of Arrian, containing the details of Alexander's illness and death, vindicates his memory from the imputation of his having brought on his fate by intemperance. Sir Henry Halford closed his learned and interesting paper by a brief encomium upon the character of Alexander, in the course of which he remarked that the efficiency of the British army in India, which kept millions of natives in subjection, was maintained by the same measures which Alexander devised and executed.

Mr. Grote, in his *History of Greece*, maintains that the cause of the fever of which Alexander died was intemperance.

Sir Thomas Browne thus notices the reputed poisoning of Alexander: "Surely we had discovered a poison that would not endure Pandora's box, could we be satisfied in that which for its coldness nothing could contain but an ass's hoof, and wherewith some report that Alexander the Great was poisoned. Had men derived so strange an effect from some occult or hidden qualities, they might have silenced contradiction; but ascribing it unto the manifest and open qualities of cold, they must pardon our belief, who perceive the coldest and most Stygian waters may be included in glasses: and by Aristotle, who saith that glass is the perfectest work of art, we may understand they were not then to be invented."—*Vulgar Errors,* b. vii. c. xvii.

DEATH OF CLEOPATRA.

Cleopatra was present at the decisive battle of Actium, September 2, 31 B.C., and she set the example of flight, which was followed by Marc Antony. He attempted suicide, but the wound did not produce immediate death. Cleopatra, when she heard the cries of anguish, and recognised the voice of Antony, despatched a messenger to bid him to join her in her tower, whither she had retreated. Antony, pale and bleeding, was raised into the tower by a rope, and here he breathed his last, in the arms and upon the lips of Cleopatra. She then committed suicide, in order to avoid the humiliation of being led in the triumphal procession of Octavianus. Most probably she took poison. According to the story in Plutarch, she was closely watched by the order of Octavianus, who suspected her design; but an asp, the reptile she had chosen for her purpose, was brought her by a peasant in a basket of figs. After using her bath, and partaking of a sumptuous supper, she applied the deadly serpent to her arm. Before retreating to her monument or tower, she wrote to Cæsar, who discovered in the tone of her address an earnest of her secret resolution. He despatched his guards in haste; but Cleopatra was no more. When the door of her apartment was burst open, she was dead; her beauty was yet unimpaired. She lay beneath a canopy of white Pelusian, dropped with gems, upon a golden couch of gorgeous workmanship, attired in all the ornaments of royalty; one of her attendants lay dead by her side, and the other had just strength enough remaining to arrange the diadem on the head of her mistress.

The *Asp* has thus obtained celebrity as the instrument of death selected by Cleopatra. It is often mentioned both by Greek and Roman writers: its modern Arab name is *El Haje,* and it is closely allied to the cobra capello, or spectacled snake of India. Its poison is of the most deadly nature. The habit which this serpent has of erecting itself when approached, made the ancient Egyptians imagine that it guarded the place which it inhabited. They made it the emblem of the divinity, whom they supposed to protect the world; accordingly, they have represented it on their temples sculptured on each side of a globe.

POISON-RINGS OF THE ANCIENTS.

Many cases are recorded of suicide by the ancients by means of rings made with hollow beads to receive a small drop of concentrated poison, of the class called acro-narcotic. Thus, M. Crassus, when arrested on a charge of purloining from the temple of Capitoline Jove an immense amount of gold deposited there by Camillus, broke the hollow receptacle of his ring between his teeth, and falling, expired on the spot. Hannibal's death is said to have been occasioned by a ring:

> Not the swift sling nor strenuous spear shall harm
> The life that held the nations in alarm;
> A ring, behold, the debt of vengeance pay,
> And all the blood which blends with Cannæ's clay.

And to mention but one other instance, the illustrious Demosthenes met his death in a like manner, and for a like reason.

THE POISON-BOWL OF CAPUA.

On the night before Capua capitulated to the Romans, seven-and-twenty of the chief nobles of that city were invited by Vibulus Varius to a funeral feast, in anticipation of their own death. After supper, when they were filled with meat and drink, the host, himself setting the example, quaffed a bowl of poison, and then handed it round to his guests, who drank each man his share ; and after a final embrace, all separated. Some die that night, many early in the morning ; but the whole band ha ceased to exist before the Romans forced a way into Capua th next day.—*Fraser's Magazine*, No. 317.

POISONING BY ARSENIC.

We have already glanced at the properties of metallic Arsenic and now propose to consider a few of the effects of its compounds rendered serviceable in medicine ; but science ha unfortunately enabled wicked men to increase and multiply the means of its employment as a poison, and at the same time to baffle detection by the most subtle art.

The white arsenic of the druggists is the arsenious acid : it has not the garlic smell, and is a virulent poison, which is not the case with the metal. The detection of arsenious acid in complex mixtures containing organic matter and common salt, as beer, gruel, soup, &c., or the fluid contents of the stomach in cases of poisoning, is a very difficult problem ; the organic matters rendering the indications of the liquid tests worthless.

Marsh's method is extremely delicate. The suspected liquid is acidulated with sulphuric acid, and placed in contact with metallic zinc; the hydrogen reduces the arsenious acid and combines with the arsenic, if any be present. The gas is burned at a jet, and a piece of glass or porcelain held in the flame, when any admixture of arsenetted hydrogen is at once known by the production of a brilliant black metallic spot of reduced arsenic on the porcelain. (*Fownes's Manual.*) The zinc and the sulphuric acid should be previously examined in the apparatus, as they often contain traces of arsénic.

Reinsch's test with copper-wire is also very delicate. By dissolving a grain of arsenious acid in a pint of distilled water, arsenic has been detected at a dilution of 560,000 times ; and at 280,000 times the liquor is so strong as to be fit for sublimation, having a bright steel colour.

White arsenic is generally said to be in taste acrid and corrosive ; but Dr. Gordon states it to be *at first* always sweet, but afterwards somewhat acid. It is not so poisonous as Prussic acid and strychnia, while its curative influence is very great. A small quantity, as $\frac{1}{30}$ or $\frac{1}{15}$ of a grain, acts as a tonic; but this statement should not lead any one to make a hasty or inconsiderate use of this very powerful agent, which should be left in the hands only of the most skilful medical practitioners. Before its regular introduction, combined with potass, it was employed in Lincolnshire for the cure of intermittent fevers, under the name of the *Tasteless Ague Drops.* In rheumatisms, neuralgia, heart-burn, epilepsy, hydrophobia, tetanus, cancer, and skin-diseases, arsenic is given by regularly-educated practitioners, but should never be used as a domestic or household medicine.

Marvellous stories are related of the common people *eating arsenic* in Lower Austria and Styria, and thus giving plumpness to the figure, and beauty and freshness to the complexion, and easy breathing to persons climbing steep and continuous heights. We have known arsenic given to horses among their corn, to improve their coats and condition; here it is a stealthy practice, but in Austria it is openly followed.

The want of care and exactness in the quantity of arsenic, and the frequent change of servants, have doubtless occasioned the loss of many valuable horses, whose deaths have remained a mystery; for it is a wonderful fact with regard to the taking of arsenic, that if it be discontinued, the constitution breaks up with precisely the same symptoms which are produced by arsenical poisoning; and the sufferer (the effect is the same on the man as on the horse) dies a miserable death from want of arsenic, with every appearance of being the victim of poison.

The subject is, however, beset with contradictory evidence. At the meeting of the British Association in 1859, a remark made by Mr. Trevelyan, that it was the opinion of some that arsenic, when taken in small quantities, was not deleterious, brought forth a warning from Professor Daubeny, not to put any faith in the statement in Dr. Johnston's *Chemistry of Common Life*, that arsenic is taken by the girls of Tyrol to improve their complexion, and that when taken constantly the system becomes used to it, *that* being the reverse of the fact. Mr. Liveing observed, he had heard this use of arsenic had been told to Dr. Johnston by a practical joker, who did not like to confess the imposition after it had been made public. Now, in Johnston's work, vol. ii. pp. 201-204, Dr. Von Tschudi, the traveller, is quoted as the authority.

Arsenic has been detected in vinegar, conveyed in the sulphuric acid with which vinegar is adulterated. To diminish the crystallising force of fatty acids in candle-making, arsenious acid was formerly employed; but the "arsenic candles" were soon driven out of consumption, and the manufacturing effect is now produced by regulation of temperature. The arsenic of copper in green paper-hangings is liable to be blown or brushed off, dispersed in the apartment, and inhaled. Prof. Lain, of Besançon, has proved there to be arsenic in the wire of which pins are made, three or four giving a perceptible quantity:* "never put pins in your mouth." Fly-paper, "Papier Mouré," has been found to bear arsenious acid enough in four sheets to destroy a human life. Artificial Manures (as superphosphates) being prepared with sulphuric acid which contains arsenic, it may be absorbed by plants grown with such manures, and the poison be thus conveyed into our systems. Arsenic ha long been used in steeping grain for seed; when it preserve the seed from decay, kills the vermin which might devour it and converts them into manure. Arsenite of copper, used fo colouring confectionery green, has poisoned many children Shot (arsenic and lead), from being left in wine-bottles i washing, and afterwards dissolved in wine, has often produce colic in the drinkers, if not death.

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* Possibly this may be from the sulphuric acid in the *pickle* for the pins.

Orfila at one time thought he had satisfactorily prove arsenic to be a normal constituent of the bones of man; a opinion which, if confirmed, would have gone far to render inoperative chemical testimony in relation to the unfair or criminal presence of that body. Orfila subsequently altered tha opinion; but more recent chemical investigators have demonstrated the presence of arsenic in sources where it would hav been little suspected. Amongst others, that metal has bee proved to exist invariably in the ochreous deposits which certain varieties of natural water throw down. Cognisant of thi fact, Prof. Otto, of Brunswick, examined for arsenic the crus which had formed inside his tea-kettle; and by the applicatio of Marsh's test he proved the presence of arsenic. The wate used in London deposits a large amount of crust in tea-kettles it holds a variable portion of oxide of iron, and probably, i subjected to chemical tests, it will be found to contain arsenic

In a paper in *Silliman's Journal*, 1859, it is stated that th larvæ which consumed some rats that had been poisoned wit arsenic and flyblown, were not affected by it, although it i well known that flies themselves are quickly destroyed b arsenic.

HOW THE NETTLE STINGS.

Prof. Wills, of Giessen, having ascertained the liquid in th poisonous organs of some insects to be *formic acid*, considere it probable that the same acid occurred in plants, which by thei stinging hairs produce effects analogous to the sting of certai insects. Acting on this suggestion, Dr. Gorup-Besanez has detected formic acid in various stinging-nettles. It exists i minute quantities, and is supposed to be contained only in th stinging hairs, from its being observed that when a solution silver is applied to the plant under the microscope, with a ge tle heat, reduction always first occurs at the extremity of th stinging hair. In other words, this is done by the cuticle of th plant being extended into rigid hairs or bristles, which hav venom at their root, and a portion of which is conveyed throug them into the wound they inflict. The construction of thi sting may be considered analogous to that of the serpent. Mi

Curtis, in his *Flora*, has thus minutely described the stinging process:

> The naked eye readily perceives the instruments by which the nettle instils its poison; but a microscope of no great magnifying power more plainly discovers them to be rigid, transparent, tubular setæ, prickles, or stings, highly polished, and exquisitely pointed, furnished at their base with a kind of bulb, in which the juice is principally contained; and which, being pressed on when the sting enters the skin, forces the poison into the wound.
>
> "Of the venomous quality of this liquid I have had ocular proof. Placing the foot-stalk of a nettle-leaf on the stage of a microscope, so that the whole of the prickle was in the focus when horizontally extended, I pressed on the bulb with a blunt-pointed pin, and after some trials found a liquid to ascend in the prickle, somewhat as the quicksilver does when a warm hand is applied to the bulb of a thermometer. In some of the prickles I observed the liquid stationary. Or pressing such in particular, I saw most plainly the liquid ascend to, and flow most copiously from, its very extremity. I was the more anxious to see this, as I suspected the poison might proceed from an aperture in the side of the sting near the point, as in the forceps of the spider and tooth of the viper; and here it appears to be placed, rather than at the extremity, that it may not take off from its necessary sharpness. Pricking the skin of my hand with a needle, I placed some of the juice in the wound, when it instantly inflamed, and put on all the appearance of a part stung by a nettle."

Yet the soft and fleshy caterpillar crawls and feeds on the nettle with impunity, reminding us how the Giver of all good "tempers the wind to the shorn lamb."

The effects of the European nettle are not, however, to be compared with those of some Indian species. M. Leschesnault describes a nettle at Calcutta, the pain from the sting of which lasted nine days. The sensation, when water was applied to the stung part, is described as if boiling oil had been poured over the skin. Still more virulent, however, is the sting of the nettle in Timor, the largest of the Lesser Sunda Islands; its effects being said by the natives to last for a year, and sometimes even to cause death.

HYDROCYANIC, OR PRUSSIC ACID,*

Discovered as early as 1782, by Scheele, has a very powerful odour, much resembling that of peach-kernels or bitter-almond oil. In the anhydrous state, this substance is one of the most formidable poisons known; and even when largely diluted with water, its effects upon the animal system are exceedingly energetic. It is employed, however, in medicine in very small doses. The acid in its pure state can scarcely be preserved even when enclosed in a carefully-stopped bottle; it oon darkens, and eventually deposits a black substance containing carbon, nitrogen, and perhaps hydrogen; ammonia is formed at the same time, and many other products. Light favours this decomposition.

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* See *ante*, page 83.

Bitter almonds, the kernels of plums and peaches, the seeds of the apple, the leaves of the cherry-laurel, and various other plants belonging to the great natural order *Rosaceæ*, yield on distillation with water a sweet-smelling liquid, containing hydrocyanic acid. This is probably due in all cases to the decomposition of the *amygdalin*, preëxistent in the organic structure. The change in question is brought about in a very singular manner by the presence of a soluble azotised substance, called *emulsin* or *synaptase*, which forms a large proportion of the white pulp of both sweet and bitter almonds. Hydrocyanic acid exists ready formed to a considerable extent in the juice of the bitter cassava.

We are perhaps most familiar with hydrocyanic acid in the smell of the wall-flower and hawthorn. It exists in the leaves of the common laurel so largely, that a water distilled from this is almost instantaneous poison. This fact was discovered at Dublin in 1728 (fifty-four years previous to Scheele's discovery), where several persons who had used it as a cordial, mixed with spirits, were poisoned. Yet the flavouring so commonly used for custards and farinaceous puddings contains a large proportion of this deadly poison.

Prof. Santi, of Pisa, many years since wrote an interesting little work to show that ratafia had long been made with Italian laurel-leaves. Kirschwasser is drawn from the stones of cherries chiefly grown in the environs of the Black Forest: according to Le Normand it is "downright" poison. In Paris, a spurious Kirschwasser is distilled from the kernels of prunes.

The only immediate remedy, of safe application by a non-medical person, for poisoning by Prussic Acid, or any vegetable substance containing it, is pouring a stream of cold water from some elevation upon the head and spine of the patient. The lives of many have been saved by this very simple means being resorted to immediately, while the delay of a few minutes would have proved fatal. The effect of this poison is narcotic; and owing to its rapid action on the nervous system, a convulsive contraction of the muscles of the jaw generally prevents the administration of emetics.*

Cyanide of Potassium, one of the compounds of this class, is used in considerable quantity in electro-plating and gilding, and has lately been derived from a curious and unexpected source. In some of the iron-furnaces of Scotland, where raw coal is used for fuel with the hot-blast, a saline-looking substance is occasionally observed to issue in a fused state from the tuyere-holes of the furnace and concrete on the outside: this proves to be cyanide of potassium.

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* From *British Poisonous Plants.* By Charles Johnson, Botanical Lecturer at Guy's Hospital. With coloured plates. Sowerby: Lambeth. (This is an excellent work of authority.)

STRYCHNINE AND STRYCHNOS.

Strychnine, or Strychnia, is usually prepared from the peltiate seeds of Strychnos, which are commonly termed Nux Vomica, rat's-bane, poison-nut, or Koochta. Strychnos is a tropical bush, growing to the size of a tree, on the Malabar and Coromandel coasts of the Indian peninsula. It bears a cluster of minute flowers and small orange-like fruit. The seeds are imbedded in a white gelatinous pulp, which seems harmless, being greedily eaten by many sorts of birds. The seeds alone form the fatal drug. The wood of the tree is, however, intensely bitter, and is employed in the cure of intermittent fevers and the bites of venomous snakes; indeed, Strychnine itself is an important remedial agent. In very small and repeated doses it promotes the appetite and assists the digestive process. It is employed medicinally in paralysis, dyspepsia, dysentery, affections of the nervous system, &c. In India, the seeds were used in Dr. Roxburgh's time to increase the intoxicating quality of country spirits. At Jellasore, in the Zillah of Midnapore, East Indies, the bush grows (as to its berries) in great and wild abundance. It is remarkable for its encouraging the most deadly snakes amid its branches: here the *cobra capello* takes up its abode.

From the bark of the root of the *Strychnos tienté* is obtained "the frightful poison" called "tjettek," and "upas radja." Another species is employed by the American Indians to poison their arrows; it causes immediate death when introduced into the slightest wound. This plant is also the "upas-tree" of Java;* but being a climbing plant, is different in general habit and botanical characters from the half-mythical upas of which so many fearful fables of death are narrated. The name of Upas has, however, become associated with a great number of poisonous trees throughout Asia. The true Upas-tree is the *Antiaria toxicaria*, which yields the Antiar poison; but the seeds are wholesome. Its venom is due to the same chemical substance, Strychnine, which constitutes the *Strychnos nux vomica*. Dr. Lindley observes that, although much error has been written regarding the Upas, there remains no doubt that it is a plant of extreme virulence; even linen fabricated from its tough fibre being so acrid as to verify the story of the shirt of Nessus, for it excites the most distressing itching if insufficiently prepared.

* See "The Upas-tree of Java," *Things not generally Known*, First Series, p. 99.

Strychnine is used medicinally in very small quantities, and has no other legitimate application. Its consumption is, therefore, unaccounted for: twelve years since a ton of this article would have been a large annual import, whereas it now exceeds sometimes 100 tons.

An over-dose of strychnine produces tetanus (lock-jaw) and death; a medicinal one (one-ninth of a grain three times a day, for example) restores the sensation of paralytic limbs. The sulphate of strychnine has marked effects in doses of one-twelfth of a grain. One of Dr. Bardsley's patients, in Lancashire, who was experiencing the return of sensation in his paralysed limbs under the use of strychnine, asked if there was not something *quick* in the pills; *quick* for *alive* being still in use in that part of England.

The painful interest associated with this poison has been much increased of late years by the frequency of its employment for criminal purposes; thus rendering its detection an important process, which has been sometimes attended with uncertain results in medico-legal inquiries. Mr. W. B. Herapath, in a communication to the Royal Society, states that in one experiment he took 1-1000th part of a grain of strychnine only, and produced ten crystals of nearly equal size: of course each one, possessing distinct and decided optical properties, could not represent more than the 1-10,000th part of a grain; in fact, it really represents much less, inasmuch as one portion of the strychnia is converted by substitution into a soluble hydriodate, and of course remains dissolved in the liquid. In this experiment diluted spirit of wine is used—one part spirit to three of water; the smallest quantity of tincture of iodine is the re-agent, after employing heat for a short time, to set it in repose. On spontaneous evaporation or cooling, the optical crystals deposit themselves, and may be recognised by the polarising microscope.

Mr. F. Horsley, in a paper read to the British Association, maintains it to be as much out of the power of any human being to define the limits of sensibility which he has attained, as it would be to count the sands or measure the drops of the ocean. Taking 30 drops of a solution of strychnia containing half a grain, he diluted it with four drachms of water. He then dropped in six drops of a solution of bichromate of potass, when crystals immediately formed, and decomposition was complete. Splitting up the half-grain of strychnia into millions of atoms of minute crystals, he said that each of these atoms, if they could be separated, would as effectually demonstrate the chemical characteristics of strychnine as though he had operated with a pound-weight of the same.

Dr. Marshall Hall observes, that when the chemical test fails, there remains the physiological; and he considers the effect on the most excitable of the animal species (the frog) to be at once the most delicate and specific test of this poison.

He placed one frog, fresh from the pools, in an ounce of water containing the 1-50th part of a grain of the acetate of strychnia; a second in the same quantity of water, containing the 1-66th; a third, containing 1-100th; and a fourth, containing 1-200th. All became tetanic in two or three hours, except the third, which was a female (the others being males), which required a longer time. Next was placed a male frog in 1-400th part of a grain of the acetate of strychnia dissolved in six drachms of water. In three hours and a half it became violently tetanic. In two other experiments, the 1-500th and the 1-1000th of a grain of the acetate of strychnine were detected.

Professor Kölliker, of Wurzburg, has shown that—1. The Antiar is a paralysing poison. 2. It acts, in the first instance, and with great rapidity (in five to ten minutes), upon the heart, and stops its action. 3. The consequences of this paralysis of the heart are the cessation of the voluntary reflex movements in the first and second hour after the introduction of the poison. 4. The Antiar paralyses, in the second place, the voluntary muscles. 5. In the third place, it causes the loss of excitability of the great nervous trunks. 6. The heart and muscles of frogs poisoned with Urari may be paralysed by Antiar. 7. From all this it may be deduced that the Antiar principally acts upon the muscular fibre, and causes paralysis of it.—*Proc. Royal Society.*

Professor Johnston maintains the bitter substance of strychnine to be so intense, that its taste can be detected in 600,000 times its weight of water.

It was long an opinion that strychnine was evanescent, and difficult, if not impossible, to detect after death; but this poison has been obtained from bony tissue long after the death and putrefaction of the victim who had been poisoned by repeated small doses of this drug. Nicotine has been more than once used with success to counteract strychnine.

THEORY OF POISONS.

Why compounds with so nearly the same elements as oxalic acid and sugar, Prussic acid and common vinegar, &c., should have such opposite effects upon the living frame, we can no more explain than we can why Ipecacuanha should excite vomiting; but we know the facts well and can turn them to very useful account. Among the substances rendered interesting by their powerful action as poisons, there are among vegetables strychnia, aconite, tobacco, Prussic acid, belladonna, &c. Among animals, there are the venom of serpents, the poison of stings, the saliva of the mad dog, &c.

The protecting power of some substances is imperfectly understood. It is, however, known to be connected with the general theory of poisons; and to this we must probably ascribe the fact that several poisons which are fatal, when applied to a wounded surface, may be taken into the stomach with impunity.

VENOM OF SERPENTS.

Dr. J. Gilman, of St. Louis, states that the process of robbing Serpents of their Venom is easily accomplished by the aid of chloroform, a few drops of which stupefy them; and when under its influence, the poison may be taken from out of the fang; but in two days a serpent so robbed has been found as highly charged as ever with venom. Dr. Gilman inoculated several healthy vegetables with the point of a lancet well charged with the venom: next day they (the plants) were withered and dead, as though they had been scathed with lightning; so that the venom destroys all forms of organised life, vegetable as well as animal. Dr. Gilman also maintains that serpents possess the power of fascinating small animals, and that this power is identical with mesmerism.

Mr. Francis Buckland, in his deservedly popular *Curiosities of Natural History*, tells us that

> The Poison of the Viper consists of a yellowish liquid secreted in a glandular structure (situated immediately below the skin on either side of the head), which is believed to represent the parotid gland of the higher animals. If a viper be made to bite something solid, so as to void its poison, the following are the appearances under the microscope: At first nothing is seen but a parcel of salts nimbly floating in the liquor, but in a very short time these saline particles shoot out into crystals of incredible tenuity and sharpness, with something like knots here and there, from which these crystals seem to proceed, so that the whole texture in a manner represents a spider's web, though infinitely finer and more minute. These spiculæ, or darts, will remain unaltered on the glass for some months. Five or six grains of this viperine poison, mixed with half an ounce of human blood, received in a warm glass, produce no visible effects, either in colour or consistence; nor do portions of this poisoned blood, mixed with acids or alkalies, exhibit any alterations. When placed on the tongue, the taste is sharp and acrid, as if the tongue had been struck with something scalding or burning; but this sensation goes off in two or three hours. There are only five cases on record of death following the bite of the viper; and it has been observed that the effects are most virulent when the poison has been received on the extremities, particularly the fingers and toes, at which parts the animal, when irritated (as it were, by an innate instinct), always takes its aim.

POISONOUS FUNGI.*

The action of Fungi is variable, some of the reputed wholesome species even proving poisonous to certain constitutions, and the contrary. Dr. Lindley, after enjoining the utmost caution in employing Fungi, the nature of which is not perfectly ascertained, in consequence of the resemblance of the poisonous and wholesome species, adds, "but the greatest caution and knowledge will not always avail, for certain species which are in general perfectly wholesome sometimes produce very disastrous consequences. A family at Cambridge a few years since suffered from eating mushrooms; a part of what were gathered proved to be a species sold sometimes in the London markets, and ascertained by Mrs. Hussey, who has paid great attention to the subject, to be most excellent for food. The case perhaps is similar to that of the prejudicial effects sometimes experienced after eating mussels, and may be considered as a mere exception."

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* Some species of Fungi contaminate the air, and render it unfit for respiration, by absorbing oxygen, and exhaling carbonic acid: in a chemical point of view, they are like animals without motion.—*Liebig.*

M. Desmartine and M. Corne, of Bordeaux, have proved that a variety of Mushroom called poisonous is not necessarily poisonous *for every locality*,—that climate and soil, in fact, modify the nature of mushrooms to an extraordinary extent. For example, the *Amanita rubra* of Lamarck is described by all authors as a violent poison ; nevertheless the inhabitants of Bordeaux eat this fungus with impunity, merely roasting it on coals. Indeed, this particular kind of mushroom is a luxury in the neighbourhood of Bordeaux.

Dr. Daubeny, of Oxford, says: "Judging from the present state of our knowledge, it would rather seem as if poisonous fungi may act as ferments when introduced into the system, and thus set up a series of changes in the vital fluids which are incompatible with life.

"This will explain the circumstance, otherwise incomprehensible, *why the same fungus which operates as a poison upon one person does not affect another*; and why certain nations, as the Russians, either from national want of susceptibility or from habit, use as articles of food several kinds of mushrooms which are rejected by us as poisonous.

"They also are equally capricious in their operation, and produce effects entirely incommensurate to the minuteness of the quantity of them imbibed. It is not indeed necessary to account for this by supposing them to act as ferments; for the property of reproduction, which we must in any case ascribe to the poisonous principles which give rise to these effects, might account for the malignity of the result proceeding from a cause originally so insignificant; but at any rate, the fact is quite in harmony with the process which takes place during fermentation, where the minutest quantity introduced into a fluid susceptible of change is sufficient to operate upon the entire mass."—*Jameson's Edinburgh Philosophical Journal.*

IMPURE WATER AND CHOLERA.

Dr. Daubeny, in the paper just quoted, has observed that among the modes by which Cholera poison is disseminated, one of the most frequent perhaps is the Water used for drinking. Pure water, so far as we know, is not capable of receiving or generating the infectious principle of Cholera; but *impure* water seems to be one of the readiest means of conveying it into the system. There is a curious illustration of this fact in the comparative exemption from Cholera which was enjoyed by the parts of London supplied with pure water during the epidemic of 1849.

It appears that whilst in the district supplied with water by the Lambeth, Chelsea, and Southwark Companies the mortality was 123 in 10,000, that in the districts supplied by the New River, East London, and Kent Companies, was 48; and in those supplied by the Grand Junction and Middlesex, only 15. Now the Lambeth, Chelsea, and Southwark Companies obtained their water from the Thames, between Battersea and Waterloo Bridge; the New River, East London, and Kent Companies from tho Lea and the Ravensbourne; the Grand Junction and the West Middlesex both from the Thames, but the former as high up as Kew, the latter at Barnes.

Now mark the proportion of deaths during the epidemic, in the six weeks prior to October 7, 1855. It is stated from official returns, that in the population supplied by the Southwark Company, the mortality was 85 to 10,000 inhabitants; in those which obtained their water from the Kent Company, only 19; whilst in the case of those furnished by the Lambeth Company, where the mortality in 1849 was no less than 123, it now was only 17. But this comparative exemption is accounted for by the circumstance that, whereas in 1849 this company was supplied from the river at Lambeth itself, it now (1855) draws its consumption from the Thames at Thames Ditton. No facts would seem more conclusive than these with respect to the unwholesomeness of water obtained from a river polluted with animal impurities.

It is true that Dr. Hassall, in his microscopic examination of the water supplied to London, condemns all the water-companies alike, exhibiting in his plates a formidablo display of animalcules derived from every one of them.

But the presence of animalcules does not necessarily render water unwholesome; and with respect to the amount of sewage, or of dead animal matter, there can be no doubt that there must be a great difference between water brought from the Thames near London itself, and from spots several miles higher up.

Disinfection appears to be a costly process; for, during the season of 1859, the disinfectant agents poured into the sewers and sluices discharging themselves into the river were, about 4281 tons of chalk-lime, 478 tons of chloride of lime, and 56 tons of carbolic acid, at a cost of 17,733*l*.

Hippocrates.

WHAT HIPPOCRATES KNEW OF MEDICINE.

HIPPOCRATES, born at Cos, B.C. 460, was the first person who applied himself to the study of physic as the sole business of his life: hence he obtained the title of "the Father of Medicine." His family followed the pursuit of medicine for near three hundred years, and produced seven physicians, who are supposed to have written the numerous treatises which are commonly attributed to Hippocrates alone.

The principles of Hippocrates were those of rational empiricism.[*] He did not attempt to form his theories from *à-priori* reasoning, but from his observation of the phenomena of nature. He taught that the body is composed of four primary elements —fire, water, earth, and air; that these elements, variously combined, produce the four cardinal humours, and these again the different organs of the body. His knowledge of anatomy was very limited, from the superstitious respect paid to the dead by the Greeks preventing the dissection of the human body. He gives such descriptions of the bones as show that he had indeed studied the subject, but not acquired any very accurate knowledge; he does not seem to suppose that the vessels originate either in the heart or liver. Under the term "nerves," he confounds all the white tissues of the body, the nerves properly so called, the tendons, and ligaments. According to Hippocrates, the brain is glandular, and secretes the pituita, or mucus. His pathology relates principally to the investigation of the remote causes of diseases, without much speculation on their nature. However, he explains inflammation by the passage of blood into those parts which did not previously contain it. He paid great attention to the effects of change of air, warmth, moisture, food, upon its phenomena, and those of disease; and he recommended particular attention to the constitution of the seasons.

Among the doctrines of Hippocrates is that of *Critical Days.*[†] He says, fevers come to their crises on the same days, both those which turn out fatally and those which turn out well. These days are the fourth, the seventh, the eleventh, fourteenth, seventeenth, and twentieth. The next stage is of thirty-four days, the next of forty, and the next of sixty.

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[*] Empiricism was the practice of physic by experience alone, discarding as unnecessary all acquaintance with the structure of the body, or reasoning on its functions.

[†] Dr. Cullen adopted this doctrine of Critical Days. (See *Things not generally Known*, First Series, p. 146.) But Cullen, we must recollect, was in the habit of repeating, "There must be a tub to amuse the whale."

Of the indications to be drawn from the examination of the pulse, Hippocrates was not aware; and the word *sphygmas* is employed by him to denote some violent pulsation only.

It is, however, upon the accuracy with which he observed the leading features of disease, and his vivid descriptions of them, that the fame of Hippocrates is principally and justly founded. Nowhere is the peculiar power of the Greeks in expressing their conceptions more strikingly shown. These marked descriptions are extracted from his *Prognostica:*

"If the appearance of the patient be different from usual, there is danger. If the nose be sharp, the eyes hollow, the temples collapsed, the ears cold and contracted, and the lobes inverted, whilst the skin of the forehead is hard, dry, and stretched, and the colour of the face pale or black or livid or leaden, unless these appearances are produced by watching or diarrhœa, or under the influence of malaria, *the patient is near death.* This description has obtained the title of *Facies Hippocratica.*"

Again, how well does he recommend us to observe the position of the patient in bed. "If he lies upon his side, with the neck and arms slightly bent, and the whole body in a flexible state, since such is the position of health, it is well; but if he lies on his back, with the legs and arms extended, and still more if he keeps sinking towards the bottom of the bed, or tosses his arms and head into unusual positions, our anticipations must be most unfavourable." And, "if in acute diseases, the hands are waved before the face, as if seeking something in the air, and brushing or picking motes from the walls or bed-clothes, the prognosis must be unfavourable."

It is clear that the idea on which is founded the modern art of Auscultation (observation of disease as denoted by sound) had occurred to Hippocrates upwards of 2000 years ago. "You will know by this," says he, "that the chest contains water, and not pus, if, on applying the ear for a certain time to the side, you hear a sound like that of boiling vinegar." The non-existence of dissection prevented the following out to any sure and useful results this idea, which had occurred to the most ancient writer on physic. Accordingly, the suggestion of Hippocrates seems to have attracted no attention for many centuries. Hooke, the mathematician, not of the medical profession, and who was unacquainted with the writings of Hippocrates, said:

"There may be a possibility of discovering the internal motions and actions of bodies by the sound they make. Who knows but that, as in a watch, we may hear the beating of the balance, and the running of the wheels, and the striking of the hammers, and the grating of the teeth, and multitudes of other noises,—who knows, I say, but that it may be possible to discover the motions of the internal parts of bodies whether animal, vegetable, or mineral, by the sounds they make? that one may discover the works performed in the several offices and shops of a man's body, and thereby discover what engine is out of order, what works are going on at several times and lie still at others, and the like? . . . . . . I have been able to hear very plainly the beating of a man's heart; the stopping of the lungs is easily discovered by the wheezing."*

Hooke's prediction was realised, though not fully until the present century (1816), in the Stethoscope, or chest explorer, of Laennec; so that it took nearly two thousand years to carry out the idea of Hippocrates. His statement is in itself incorrect; but the fact of his having actually practised auscultation is no less interesting.

Hippocrates claims to have been the first to recognise the importance of Diet in the treatment of disease which had been previously neglected. In his general practice, he employed purgatives, some very violent, as the black and white hellebore and elaterium. To relieve the head in certain diseases, he used sternutatories; so that the "eye-snuff" of our day is a piece of antiquity. In acute affections, when the disease was violent, Hippocrates employed bleeding, and recommended that blood should be taken from as near the affected part as possible. This was the origin of bleeding in pleurisy from the arm on the side affected. He also made use of cupping-glasses, with and without scarification. Certain diuretic and sudorific medicines also entered into his pharmacopœia; and he was not ignorant of the virtues of the poppy.

His knowledge of anatomy and physiology, and of the processes which go on in the body during health and disease, was extremely deficient; but in the accuracy with which he observed the symptoms of disease, and in the fidelity of his descriptions, he has rarely, if ever, been surpassed. In these respects he had reached a boundary which it would have been scarcely possible to pass but by the vast body of collateral evidence which chemistry, geology, and the experimental philosophy of our times, have supplied.

Hippocrates strongly advocated the use of Cold Bathing; and Dr. Sir John Floyer, in his curious Essay, devotes an entire letter to Hippocrates' opinion "concerning the Nature of Cold Baths, and their Usefulness."

THE FIRST APOTHECARIES' HALL.

Pharmacy and chemistry are much indebted to the Arabs, who, after the fall of the Roman empire, discovered several chemical preparations, and introduced several new medicine still employed by physicians. They established in the eight century the first public Apothecaries' Hall in Bagdad. W owe also to the Arabs the first legal dispensaries, in the nint century. Whilst chemistry and pharmacy were cultivated in dustriously in the East, Europe was plunged in darkness an ignorance; when, at length, a new light was kindled by Con stantine of Carthage, who established the first regular phar macy in Europe, namely, in Salerno. He called these esta blishments *stationes*, and the dispensing chemists *confectionarii*

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* From a transposition of this comparison of Hooke's may possibly have been derived the popular notion of the construction of watch-works being taken from a minute observation of the structure of the human body. The Chinese idea of a non-going watch being "dead" also favours the above association.

MEDICAL RINGS.

From very early classic times we read that doctors wor rings. Many, but not all, of these were supposed to posses hygienic properties, resident either in the metallic hoop, o the stone set in it, or else in some nostrum enclosed in the bezil Hippocrates considered a ring as necessary to complete the toile of the man of medicine, and it was probably supposed to b curative in its effects. Antoninus Musa, the physician o Augustus, used to wear a handsome gold ring which the Em peror had given him for bringing him safely through a danger ous malady; and in further acknowledgment of his services Augustus ceded to the Roman doctorate, through him, the *ju annuli*, or power of wearing the ring, with all its privileges.

There were two varieties of the *annulus medicus*, or rin medical—the one used for surgical operations, the other adopte by physicians. The surgical practitioner, with his cuffs turne up, and showing nothing on his hands but a costly ring, coul approach without difficulty, and lay them lightly on the ski of the most timid patient; and then gently exploring his way could press a spring against a lancet or *bistouri caché*, which darting forth, swift and pungent as a hornet's sting, into th vein, abscess, or artery he might design to open, was as in stantly retracted; and while the sufferer was indulging in ex pressions of indignant surprise, the operator was holding basin under the wound, and patting the excited martyr on th back, congratulating him on his admirable courage and stoi indifference to pain.

The rings of physicians, though the functions assigned t them were more diversified, produced no such strikingly effica cious effects as those of their chirurgical brethren; still the enjoyed a wide vogue, and were confidently prescribed to th sick in a great variety of maladies. Plain iron hoops, espe cially when scored with cabalistic traceries, worked, it wa affirmed, wonderful cures. Alexander Trallianus speaks wit great assurance of an iron ring of his own devising, which wa invaluable in hypochondriasis from hepatic derangements and generally for dyspeptics, disorders which we now often vainly seek to exorcise with blue-pill. It was no doubt the known magnetic capabilities of iron which first recommended rings of this metal in the treatment of diseases, and led the physicians to employ iron rings magnetised, as we do, in hemicrania and brow-agues.

The stones set in rings were supposed to exercise a still greater control over diseases than even the iron hoop, albeit well magnetised and impressed with mysterious characters or symbols. Thus, a dangerous hemorrhage, which neither sedatives, nor absorbents, nor yet astringents, could control, would cease (on the homœopathic principle of *similia similibus*) as soon as the patient put on a blood-red cornelian ring: coral, which, in a ring, the ancients prized much more than the moderns, was, on the authority of Metrodorus and Zoroaster, an infallible remedy for, as well as antidote against, nervousness and causeless fears; wine-coloured amethysts protected their wearers from intoxication, and all its pathological consequences; hyacinths secured sleep as infallibly as opium; agates stood high in the esteem of most mineralogist doctors for the cure of the blindness *amaurosis*, or *gutta serena*;* and jaspers enjoyed great fame for their powers of discussing dropsies and driving away fevers.—*Abridged from Fraser's Magazine* 1856.

THE HEALING ART.

Two centuries ago, the qualifications for the practice of the healing art are shown by the clumsiness and cruelty with which operations were then performed; so that we must not feel surprise at the low state of medicine and surgery. Sir William Petty informs us that, even in his time, the proportion of deaths to cures in the Hospitals of St. Bartholomew and St. Thomas was 1 to 7; during 1741 the mortality had diminished o 1 in 10; during 1780, to 1 in 14; during 1813, to 1 in 16; nd in 1827, out of 12,494 patients under treatment, only 259 died, or 1 in 48. The Duke of Sussex justly said, in one of his addresses as President of the Royal Society: "Such is the dvantage which has already been derived from the improvement of medical science, that, comparing the value of life, as it s now calculated, to what it was a hundred years ago, it has bsolutely doubled." And Sir Astley Cooper asserted that the uman frame was better understood in his time by students han it had previously been by professors.

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* Milton, in the celebrated complaint on his Blindness, says:

"So thick a *drop serene* hath quench'd their orbs,
Or *dim suffusion* veiled." *Paradise Lost*, b. iii.

Physiological Chemistry.

MATERIALS OF A MAN.

Dr. Lankester has demonstrated the elementary compositio of the human body, and exhibited in the lecture-room the al solute quantities of the elements contained in it, with the e ception of four—oxygen, hydrogen, nitrogen, and *fluorin* The three first could not be exhibited on account of their bulk the last on account of its rarity.

A human body weighing 154 lbs. was stated to contai 111 lbs. of oxygen gas, which would occupy about 750 cubi feet; and 14 lbs. of hydrogen gas, which would occupy nearl 3000 cubic feet of space: the nitrogen gas would occup about 20 cubic feet. Amongst the other elements ther were 21 lbs. of carbon, 1¾ lbs. of phosphorus, 2 lbs. of th metal calcium, 1 oz. of sodium, 100 grains of iron, 15 grains of potassium, 10 grains of magnesium, and 1 grain c silicon.

These elements, when mixed together as they are in th human body, were represented by 111 lbs. of water, 15 lbs of gelatine, 12 lbs. of fat, 8 lbs. of fibrine and albumen, 7 lbs of phosphate of lime, and a variety of other salts. It wa shown that these substances are supplied to man throug the agency of plants, and that it is in the tissues of plants tha the great chemical changes go on which convert the inorgani elements into organic substances, fitted for the food of ma and animals.

HEAT OF MUSCULAR CONTRACTION.

Professor Matteucci, in a letter to Mr. Faraday, mention some new studies on *induced contraction*, or the phenomeno of the irritation of a nerve in contact with a muscle in contraction. Experiments made on the discharge of the torped led Matteucci to establish the existence of an electrical discharge in the act of muscular contraction. The general conclusion to be drawn from these researches is, therefore, tha the chemical action which accompanies muscular contractio develops in living bodies, as in the pile, or in a steam-engine heat, electricity, and *vis viva*, according to the same mechanical laws.

ANIMAL HEAT.

There is no question amongst either chemists or physiologists in regard to the general fact, that the main source of Animal Heat is the oxygenation (by a kind of combustive process) of the hydro-carbons contained in the food. Now all these hydro-carbons, such as starch, sugar, oil, &c., are either directly or indirectly derived from the vegetable kingdom; and not only a certain amount of oxygen, hydrogen, and carbon has been consumed in their production, but also a certain amount of solar light and heat, which they may thus be said to embody. The combustive process is not so carried out in the living body as to give forth light, save in a few exceptional cases; but it reproduces in the form of heat all that was embodied in the respiratory food; and thus the warm-blooded animal may be said to be continually restoring to the universe that force which the growing plant had appropriated to itself. And, carrying the principle a little further, we may say, that in utilising the stores of coal which have been prepared by the luxuriant vegetation of past ages, man is not only restoring to the atmosphere the carbonic acid and water of the carboniferous epoch, but is actually reproducing and applying to his own uses the light and heat which its vegetation drew from the solar beams, as if for the very purpose of fixing them until he should find the means of turning them to account.

Looking at this matter from the stand-point afforded by the "correlation" doctrine, we are led to question whether the project of the Laputan sage to extract sunbeams from cucumbers was so very chimerical after all; while we cannot but feel an increased admiration of the intuitive sagacity of that remarkable man George Stephenson, who was often laughed at for propounding, in a somewhat crude form, the very idea which we have just been endeavouring to present under a more philosophical form.[*]—*National Review*, No. 8.

BURNING AND UNBURNING OF THE HUMAN BODY.

Wonderful is it to reflect that every animal exists at first as a minute speck of matter called a germ or ovum, of simplest form, but in which all the vital powers are already present, under the influence of which new matter begins quickly to be selecte and taken in from around to form the compound fluid calle *blood;* and out of this blood afterwards are gradually built u all the parts and organs of bone, muscle, skin, hair, eye, ea &c. which the body in its most perfect state possesses ; an not only are the parts so built up to full size and strengt during the years of growth, but they are receiving constan support and repair (as a ship's crew may be preserved vigorou for 100 years by the constant exchanging of old men for young through the long period of middle age and gradual decline and, most wonderful of all, during the middle term of its existence the body is able to throw off germs such as it was originally itself, to continue the race through future ages.—*Arnott.*

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[*] It is believed to have been first remarked by George Stephenson, that the original source of the power of heat engines is the sun, whose beams furnish the energy that enables vegetables to decompose carbonic acid, and so to form a store of carbon and of it combustible compounds, afterwards used as fuel. The combination of that fuel with oxygen in furnaces produces the state of heat, which being communicated to some fluid, such as water, causes it to exert an augmented pressure, and occupy an increased volume; and these changes are made available for the driving of mechanism.—Prof. Rankine's *Manual of the Steam-Engine*, 1859.

Chemically, the human organism is the continual subject o swift changes of its composition in opposite directions ; an these changes have been eloquently termed by Dr. George Wilson, "the Burning and Unburning of the Human Body."

There is continual addition of matter to the body, an continual withdrawal of matter from it ; but apart from this and within the ring-fence of its own organism, a process o combustion and one the very reverse are going on togethe Here one tissue is burning like fuel, and there another is becoming the depository of combustible matter. We have as i were millions of microscopic wind-furnaces, converting int carbonic-acid gas, water-vapour, and other products of combustion, all the combustible elements of the body ; and millions of blast-furnaces reducing the starch and sugar of th food, and the sulphates and phosphates of the body, into inflammable oils and other fuels, which are finally transferred t the wind-furnaces, and burned there. *Burning,* and what w must call in contradistinction *unburning,* thus proceed together ; the flame of life, like a blowpipe-flame, exhibiting a oxidising and a reducing action at points not far distant fro each other.

CIRCULATION OF MAN AND THE WHALE COMPARED.

Those who have not considered the subject must be surprised at the quantity of blood which is propelled through the heart of any moderately-sized animal in the course of twenty-four hours. In man the quantity of blood existing in the body at any given moment is probably from thirty to forty pints. Of these an ounce and a half, or about three tablespoonfuls, are sent out at every stroke, which, multiplied into seventy-five (the average rate of the pulse), gives 1125 ounces, or seven pints in a minute; *i. e.* 429 pints, or nearly 54 gallons in an hour, and 1260 gallons, *i. e.* nearly twenty-four hogsheads, in a day. Now, if we recollect that the whale is said to send out from his heart at each stroke fifteen gallons, the imagination is overwhelmed with the aggregate of the quantity that must pass through the heart of that Leviathan of the deep in twenty-four hours. It is a general law that the pulse of the larger animals is slower than that of the smaller; but even if we put the pulse of the whale as low as twenty in a minute, the quantity circulated through the heart, calculated at fifteen gallons for each pulsation, will be 432,000 gallons, nearly equal to 7000 hogsheads, in twenty-four hours.

The consideration of this amazing quantity is, however, a subject of mere empty wonder, if not accompanied with the reflection that, in order to produce the aggregate amount, the heart is kept in constant motion; and that, in fact, it is incessantly beating, as it is termed, or throwing out the blood in the arteries, from the first period of our existence to the moment of our death, without any sensation of fatigue or even without our being conscious of the process, except it be interrupted by corporeal or mental agitation.

TRANSFUSION OF BLOOD.

In November 1667, the remarkable experiment of Transfusing the Blood of a sheep into a man was performed for the first time in England before the Royal Society, at Arundel House, Strand. The subject was a poor student named Arthur Coga, who offered himself for a guinea, which was accepted. The experiment was performed chiefly by Dr. King, in his arm, with such dexterity and ease that Coga did not wince or make the least complaint, and "found himself very well upon it." After the operation, he drank a glass or two of canary, and took a pipe of tobacco, in the presence of forty or more persons. He then went home, and continued well. "The experiment was repeated in about three weeks, when eight ounces of blood were taken from Coga, and about fourteen ounces of sheep's blood injected with equal success. This gave rise to the notion that by transfusion might be realised the alchemical reveries of an *elixir of life and immortality*. Some experiments of transfusion were next made upon the Continent; but at length a lunatic in Paris died under the second operation, which led to the immediate abolition of the process.

This very interesting inquiry has, however, been resumed by the physiologists of the present age, with the many aids of the advanced state of science. Thus, recently Dr. Brown-Séquard has presented to the French Academy of Sciences a paper, in which he endeavours to prove the two following propositions:

1st. That arterial or venous blood, from an animal of any one of the four classes vertebrata, containing oxygen in sufficient quantity to be scarlet, may be injected without danger into the veins of a vertebrated animal of any one of the four classes, provided that the amount of injected blood be not too considerable. 2d. Arterial or venous blood of any vertebrated animal, being sufficiently rich in carbonic acid to be almost black (*noirâtre*), cannot be injected in the veins of a warm-blooded animal without producing phenomena of asphyxia, and most frequently death, after violent convulsions, provided that the quantity of injected blood be not below one five-hundredth weight of the animal, and also that the injection be made not too slowly.

Dr. Brown-Séquard states that he has tranfused into the jugular vein of dogs, without any ill effect, blood of rabbits, guinea-pigs, cats, cocks, hens, pigeons, ducks, turtles, and tortoises, frogs, and eels. In rabbits and birds he has also transfused blood of other animals without any marked bad effect. He attributes chiefly to carbonic acid the phenomena which had been considered as due to differences in the blood of various species.

In many communications to the Société de Biologie, the same physiologist has related facts to prove that in the experiments of Blundell, of Dieffenbach, and of Prevost and Dumas, there were many causes of failure unknown to these experimenters which have prevented them from reëstablishing life permanently in dogs bled to death, and transfused with blood from animals of another species. These causes of failure were —1st, that too much blood was transfused at once; 2d, that the blood was not fresh; 3d, that it did not contain oxygen enough, and contained too much carbonic acid.

Dr. Brown-Séquard has ascertained that even the blood of birds, defibrinated and rich in oxygen, has been able to re-establish full and durable life in dogs weighing from 15lbs. to 20lbs., and having lost more than 16 ozs. of arterial blood, *i. e.* more blood than the dogs of Blundell had lost. From 30 to 48 grammes of bird's blood (1 oz. to 1½ oz.) have been sufficient in many cases to restore full life.

IRON IN THE BLOOD.

Among the organismal metals, Iron is *par excellence* the metal, as certainly it is by the testimony of ages, industrially the most excellent of them all. All countries have honoured the smith; and he would wonder more than he does at his own skill, if he realised that the iron which he hammers is hammered not merely by iron in his hand, but also by iron in his blood. Yet the function of this iron is so little known that, though statists have calculated how many railways might be made out of the blood-iron of a generation of mankind, the most acute and accomplished chemists tell us, to take the words of one, that "we are unfortunately perfectly ignorant regarding the special uses of iron in the animal economy." And we have to turn to a poet to find the reason why it is so useful. Alfred Tennyson, in his *Princess*, makes the father of his heroine exclaim, when his stately daughter shows no signs of relenting towards the wounded prince,

> "I've heard that there is iron in the blood,
> And I believe it."

Except nickel and cobalt, iron is the only decidedly magnetic metal; and it is more magnetic than they. It must influence the body in virtue of its magnetism in a way no non-magnetic metal could, and its magnetic condition must be continually altering. The patients of Reichenbach may sometimes have deceived themselves or him, or both, when they declared that their sensations were different according as they lay along or across the magnetic meridian; but it is certain that the iron in our bodies must be in a different magnetic condition in the opposite positions, and it is reasonable to suppose that some persons may be sensitive enough to appreciate the difference. At all events, the observations of Faraday on the magnetic condition of flesh and of living animals demonstrate that the *organismal iron is magnetically active.* We know also that magnetism cannot be developed without a simultaneous development of electricity; so that magnetic changes in the ferruginous blood and flesh must be accompanied by electrical changes. Electricity also invariably develops magnetism, and we know that electrical currents are constantly traversing the muscles and other organs. Such currents will react on the magnetic masses in their neighbourhood, and be reacted on by them, with a corresponding exaltation of the intensity alike of the electricity and the magnetism. Further, the peculiar force or polarity which acts along the nerves resembles in many respects electrical and magnetic force. It is probable that all three forces or polarities powerfully influence each other, and that the magnetisable iron of the body is continually taking part in such reciprocal actions. If, moreover, the iron in the blood-vessels, as has been suggested, becomes magnetic oxide at each half-revolution of the blood, it will be much more magnetic at each of the great crises of the circulation than at any other period.—*Dr. G. Wilson; Edinburgh Essays*, 1856.

SERVICES OF PHOSPHORUS TO THE HUMAN BODY.

The importance of Phosphorus to the human organism is shown by its invariable presence in it: as in the hardest bone and the most pulpy nerve; in one form, or rather series of forms, in the blood, in another series in the flesh-juices, in a third in the milk, in a fourth in the brain, and probably in other modifications elsewhere in the organism, and associated with all its critical changes.

Limiting our attentions to the well-known modifications of phosphoric acid, we may sketch in outline how they may render service to the body.

A child is beginning to walk, and the bones of its limbs must be strengthened and hardened. Phosphoric acid accordingly carries with it three units of lime to them, and renders them solid and firm. But the bones of its skull must remain comparatively soft and yielding, for it has many a fall; and the more elastic those bones are, the less will it suffer when its head strikes a hard object, so that in them we may suppose the phosphoric acid to retain but two units of lime, and to form a softer, less consistent solid. And the cartilages of the ribs must be still more supple and elastic, so that in them the phosphoric acid may be supposed to be combined with but one unit of base, as the uncrystalline, gelatinous metaphosphate.[*] On the other hand, its teeth must be harder than its hardest bones, and a new demand is made on the lime-phosphates to associate themselves with other lime-salts (especially fluoride of calcium), to form the cutting edges and grinding faces of the incisors and molars. All the while also the blood must be kept alkaline, that oxidation of the tissues may be promoted and albumen retained in solution; and yet it must not be too alkaline, or tissues and albumen will both be destroyed, and the carbonic acid developed at the systemic capillaries will not be exchanged for oxygen, when the blood is exposed to that gas at the lungs. So phosphoric acid provides a salt containing two units of soda and one of water, which is sufficiently alkaline to promote oxidation, dissolve albumen, and absorb carbonic acid; and yet holds the latter so loosely, that it instantly exchanges it for oxygen, when it encounters that gas in the pulmonary capillaries. Again, the flesh-juice must be kept acid (perhaps, as suggested, in electro-polar opposition to the alkalinity of the blood, as affecting the transmission of the electrical currents which are now known to traverse the tissues); and phosphoric acid provides a salt, containing two units of water and one of potash, which secures the requisite acidity. Further, in some of the serous and other liquids of the body, a changeable salt is required; and for this phosphoric acid provides, by com-

[*] Von Bibra has made the beautiful observation that those bones which are the most exposed to mechanical influences contain the largest quantity of earthy constituents (chiefly phosphate of lime). The action of this law is manifested even in different families of the same class of animals; thus, for instance, in the rasores or scraping birds, the femur contains the largest quantity of phosphate of lime; in the grallatores, or waders. the tibia; and in all other birds the humerus.—Lehmann's *Physiological Chemistry, Cavendish Soc. Trans.* vol. i.

bining with soda, ammonia, and water, to produce microcosmic salt, which is alkaline in its integrity, but by parting with the easily-lost volatile ammonia becomes alkaline.[*]

FORMATION OF BONE.

Dr. Roget has justly and beautifully said that, as sculptors, before working upon the marble, first execute a model of a coarser and more plastic material, so the first business of the arteries is to prepare a model of the future bone, constructed, not with the same material of which it is afterwards to consist, but with another of a simpler and softer nature, namely cartilage. In proportion as the fabric is enlarged, the necessity for mechanical support increases, and stronger provision must be made for resistance to external violence. The removal of the cartilage may be compared to the taking down of the scaffolding which had been erected for the intended building. But this scaffolding is not taken down at once; each part is carried away piece by piece, as the operation of fixing in their position the beams and pillars of the edifice proceeds. The way is cleared at first by the absorption of the central part of the cartilage, and a few particles of ossific matter are deposited in its room. The arteries then enlarge, and deposit granules of calcareous phosphate, which are laid down, particle by particle, in regular lines, so as to form continuous fibres, which being crossed and connected, unite from different centres, not indiscriminately, but by definite laws. Each distinct bone is formed from a certain number of ossific centres, which unite as if by a natural affinity appertaining to that bone only, and not extending to the adjacent bones.

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[*] Dr. George Wilson (*Edinburgh Essays*, 1856), from whose striking paper on "Chemical Final Causes" the above is quoted,—from his own results, and those of others in the course of agricultural analyses of bone-earth, cannot avoid inferring that several phosphates of lime exist in bones, although in the ash of the latter the nature of these salts, as they occurred in the living organism, cannot be ascertained. Dr. Wilson has accordingly felt at liberty to assume as possible the phosphates referred to in the text as existing in the child's skull and ribs.

At all periods, moreover, in the life of the body, the liquid albumen and fibrin of the blood are becoming solid albumen and fibrin in the tissues. Both are becoming, in the nursing mother, the casein of her milk, and that casein in her suckling's body is becoming the albumen and fibrin of its flesh and blood, and building up its organs in other ways.

Each of these blood-forming, flesh-forming, milk-forming, tissue-forming bodies, albumen, fibrin, and casein, and likewise their analogue gelatine, are inseparably accompanied by all their liquefactions, solidifications, and transmutations, by phosphates, which, in virtue of their mobility, are able to liquefy, solidify, and undergo transmutation as the body which they accompany does. We cannot pretend to follow these changes step by step, for they occur within the inaccessible penetralia of a living structure; but certain it is that the phosphates accommodate themselves to changes which no other salts we know could submit to.

THE USE OF SALIVA.

Dr. Bence Jones considers "the action of Saliva upon the starch we take as food is similar to that of a ferment, and causes it to undergo a change into sugar. If you take a portion of pure starch, and hold it in the mouth for only two minutes, you can obtain distinct and decided traces of sugar. If you take a solution of starch not treated with saliva, and employ the test for sugar (sulphate of copper and liquor potassæ), you have no reduction of the oxide of copper; but in the other mixture of starch and water, which has been held in the mouth for two minutes only, you may see distinctly a beautiful red line of reduced copper, the evidence of the presence of sugar. If the starch is left in the mouth for three minutes, a still more manifest action is apparent; and if it remains there five minutes, there is a distinct mass of reduced copper, which is proportioned to the quantity of sugar formed out of the starch."

THE DIGESTIVE PROCESS.

The solution of the food by the gastric juice is a chemical operation, and the gastric juice is a chemical agent, the exact nature of which is clearly ascertained. Spallanzani discovered this juice to be of an acid nature, and Dr. Prout proved this acid to be the muriatic. If meat and gastric juice be enclosed in a glass tube, and kept at the temperature of the human body, a product is obtained closely resembling the fluid formed by the solution of the food in the stomach. If meat be enclosed in a glass tube with dilute muriatic acid, and kept at the temperature of the blood, a perfectly similar product is obtained.

The muriatic acid constituting the essential ingredient of the gastric juice is conceived to be derived by an act of secretion from common salt (muriate of soda), contained in the blood. The alkali, the base of the salt, is retained in the blood to maintain the alkaline condition essential to its healthy constitution ; while the acid is liberated, and poured, in the form of gastric juice, into the stomach, to accomplish the solution of the food.

A remarkable opportunity of observing the process of digestion actually in progress in the human stomach presented itself, many years since, to Dr. Beaumont, of the United States, by examining and experimenting upon one St. Martin, a Canadian, with an orifice in his stomach, occasioned by a gun-shot wound at an early period of his life, and which never healed, although the surrounding parts cicatrised readily.

Dr. Beaumont found the inner coat of the stomach to be of a light or pale pink colour, varying in its hues according as it was full or empty. It had a soft or velvet-like appearance, and was constantly covered with a thin, transparent, viscid mucus, secreted from small oval-shaped glandular bodies beneath the mucous coat. When aliment or other irritants were applied to the inner coat of the stomach, there were seen, with a magnifying-glass, innumerable minute lucid points, and very fine nervous and vascular papillæ arising from the villous membrane, and protruding through the mucous coat, and from which distilled a pure, limpid, colourless, and slightly viscid fluid. This fluid is always distinctly acid, and is the gastric juice which converts the food into chyme. Dr. Beaumont regards, with much probability, the sensation of hunger as occasioned by a distension or repletion of the gastric vessels, which cannot discharge their contents till the stomach is irritated with food. When the food was placed in the gastric juice taken out of the stomach, the same chemical result was obtained, it being kept at the temperature of 100° Fahrenheit, which Dr. Beaumont found to be that of the stomach. This artificial digestion, however, occupied a period two or three times longer than when the gastric juice acted upon the same materials in the stomach.

Dr. Beaumont has published the times in which various articles of food are digested. A full meal of various articles of food was digested in from three hours to three hours and a half; but when the stomach was diseased, or affected by narcotics, or when the mind was agitated by anger, or other strong emotions, or when the food was taken in large masses, the time of digestion was prolonged; while, on the contrary, it was shortened when the food had been minutely divided and mingled with saliva, and when the temperature of the stomach was raised. The following is the time required for the chymification of various food, as determined by Dr. Beaumont:

	H.	M.
Venison-steak, broiled	1	35
Sucking-pig, roasted	2	30
Lamb, fresh, boiled	2	30
Beef-steak, boiled	3	0
Mutton, fresh, boiled	3	0
Pork-steak, boiled	3	15
Veal, fresh, boiled	4	0
Beef, old, hard, salted, boiled	4	15
Tripe, soused, boiled	1	0
Brains, animal, boiled	1	45
Liver of the ox, fresh, boiled	2	0
Eggs, whipped, raw	1	30
Eggs, fresh, raw	2	0
Eggs, fresh, roasted	2	15
Eggs, fresh, soft boiled or fried	3	0
Eggs, fresh, hard boiled or fried	3	30
Trout (salmon), fresh, boiled	1	30
Cod-fish, cured, dry, boiled	2	0
Flounders, fresh, fried	3	30
Salmon, salted, boiled	4	0
Oysters, fresh, raw	2	55
Oysters, fresh, roasted	3	15
Oysters, fresh, stewed	3	30
Oyster-soup	3	30
Butter, melted	3	30
Mutton-suet, boiled	4	30
Beef-suet, fresh, boiled	5	50
Cheese, old, strong, raw	3	30
Calf's-foot jelly, boiled	1	0

	H.	M.
Isinglass jelly, boiled	1	0
Gelatine, boiled	2	30
Tendon, boiled	5	50
Turkey, boiled	2	25
Turkey, roasted	2	30
Geese, wild, roasted	2	30
Chicken, full-grown, fricasseed	2	45

	H.	M.
Fowls, boiled or roasted	4	0
Duck, roasted	4	0
Rice, boiled	1	0
Cake, sponge	2	30
Custard, boiled	2	45
Dumpling, apple, boiled	3	0
Bread, wheat, new	3	30

St. Martin was still living, in 1858, when Dr. F. S. Smith, of Pennsylvania College, made certain experiments with a view of settling some undetermined questions relating to the physiological action of the stomach, particularly that of the nature of the acid contained in the gastric juice; the analyses being made upon the fluids obtained from the Canadian's stomach while digestion was in progress.

In every instance, and with all kinds of food employed, the reaction of the fluid of digestion was distinctly *acid* to litmus-paper; while that of the *empty* stomach (as shown by the introduction of test-papers through the orifice), and of the fluid obtained by mechanical irritation, was as distinctly *neutral*. The *temperature* of the stomach while digestion was in progress was about 100° Fahrenheit; when empty, about 98°. The general conclusions, from a number of experiments, are:

1. That the secretions of the stomach, when digesting, are invariably acid. 2. That the acid reaction was not due to the presence of phosphoric acid. 3. That if hydrochloric (muriatic) acid was present, it was in very small quantities. 4. That the main agent in producing the characteristic reaction was *lactic acid*.

Dr. Harley, in a paper read to the British Association at Leeds in 1858, considers that the gastric juice does not destroy the power possessed by the saliva of transforming starch into sugar; consequently the digestion of amylaceous food is continued in the stomach. The gastric juice has also the property of changing cane into grape sugar.

From experiments it has been found that the gastric juice is prevented from digesting the living stomach by the coating of mucus which covers its walls. Wherever this mucus is absent, the gastric juice attacks the walls of the living stomach, and dissolves them, causing perforations and death. As regards the bile, it seems that this secretion takes an active part in rendering the fatty matters of our food capable of being absorbed into the system.

The most curious of all the digestive fluids, however, is the *pancreatic secretion*, for it unites in itself the properties of all the others. It not only transforms starch and other substances into sugar, but it emulsions fat and even digests protein compounds. As a remedy in indigestion, *pancreatine* should be greatly superior to *pepsin*, which can only digest one kind of food, namely protein. With pancreatine we should be able to digest any kind of food; and when obtained in a state of purity, it must prove an invaluable boon to suffering humanity.

When *pepsin* is introduced into the stomach, at the time of taking food, the operations of nature will be facilitated.* Now pepsin has been prepared from the rennet-bags used in making cheese. It is a syrupy solution, which, being mixed with starch and dried, forms a grayish powder, and is either used by itself or mixed with reagents which do not affect its digestive properties. Thus prepared, pepsin can be taken either in water or between slices of bread; and according to Dr. Ballard, who has introduced it into London practice, it is capable of replenishing the gastric juice of the human body. Among the cases recorded by Dr. Ballard is that of a lady, sixty-six years of age, who for four years had suffered great pain for three or four hours after every meal. The natural consequences were excessive prostration and complete disgust for food; and she had for many weeks limited herself to four rusks and a little milk and beef-tea per diem. The first day pepsin was used she ate and enjoyed a mutton-chop; in a few days she ate freely, and gradually improved; and at length was able to give up the pepsin entirely, to eat without pain, and to walk some miles without fatigue.

THE LAW OF MORTALITY.

If we relied upon our reason alone (says Mr. A. Smee), we should be led to suppose that a mechanism which had the power of self-repair, and which had the power of self-feeding, would last for ever; for we should fail to perceive by what means it could possibly stop. With respect to the mechanism of animals, including man himself, of the largest communities, one after another succumbs to death; for of children born certainly not more than one in ten thousand lives to a hundred; and of those who attain to the advanced age of a century, as certainly not more than one in twenty thousand has his life prolonged to 150: consequently, not more than one child out of twenty millions lives to the latter age.

By Gompertz's law of mortality, the sum of all the people who have as yet lived upon the earth, does not warrant the expectation of an individual attaining the greatest age which history actually reveals as having been reached; hence mathematical reasoning upon increasing numbers might lead us to infer that man is really immortal, and death but accidental. To medical science, however, death appears as inevitable as growth; and as the child is developed from the boy and grows to the man, so the man in his turn as certainly retrogrades to senility and death. We may assume that we are born with the seeds of death, and that death is as natural to man as his growth and development. I have watched with intensity of feeling my aged patients passing without disease from manhood to death; and whilst, as the result of my observations, it is merely accidental whether the retrogression takes place more rapidly in one organ than another, it is clear that death itself is not an accidental, but a normal result, neither to be averted by medicine nor parried by the mode of life. Viewing age in this light, the physician must not expect much from his skill, when he attempts to ward off a result which we are designed from birth to suffer. Nevertheless, health may be secured and life prolonged by care and the strictest attention to physical laws.

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* Liebig maintains that pepsin is nothing more than a portion of mucous membrane, or of gluten, in a state of decomposition.

The conditions of health should be rigorously followed. All external agencies, especially heat, should be duly regulated, and the diet should be most carefully adjusted to the power of digestion and the requisite amount of food. When age, unaccompanied with disease, sets in, the appetite gradually and increasingly fails, nutrition and assimilation gradually lessen; and the capacity to generate force and heat diminishes. At last, nervous power fails, and the patient silently passes into the sleep of death. To this end is man born, and must submit; for as sure as the endogenous tree grows itself to death, so does man, by virtue of some changes in his organisation, cease to evince the powers of health, and finally of life.—*Smee on General Debility and Defective Nutrition.*

VELUTI IN AQUARIUM.

The wonderful cycle of organic life in which the constituents of the atmosphere are made to pass through one living body after another, and are at last restored to it in their pristine state, is conveniently presented to the observation of every one in the Aquaria, now the fashionable ornaments of our drawing-rooms.

Every self-sustaining Aquarium ought to include three kinds of living beings, namely, plants, vegetable-feeding animals, and carnivorous animals. Thus, in a fresh-water tank we may have vallisneria, water-snails, and gold-fish; in a marine tank, some of the grass-green sea-weeds, anemonies, phytophagous gasteropods, and blennies or gobies. The plants will thrive in sunlight on the carbonic acid and ammonia diffused through the water; invisible diatoms too will increase and multiply at the expense of the same materials; the anemones and the mollusks will support themselves on the vegetable diet thus prepared for them; their eggs and young serve to sustain the predaceous fish; and while the plants are continually imparting fresh oxygen to the atmosphere of the tank, this is as constantly consumed by the animal inhabitants, which are restoring to the water during their whole lives the carbonic acid and ammonia of which the plants deprived it.—*National Review,* No. 8.

THE SOIL, THE PLANT, AND THE ANIMAL.

How much stronger at every step becomes the likeness between the Soil, the Plant, and the Animal! how much closer their connection! how much more indissoluble the union that binds them together!

When dry bone is burned, the ash that remains behind amounts to two-thirds of its weight, and consists almost entirely of phosphates of lime and magnesia, which are so abundantly present in the ash of different varieties of grain. This *bone-earth,* as it is called, must exist in the soil. The plant draws it from the earth by its roots. The cow eats it with the herbage she crops from the fields, and parts with it again in the milk she produces to feed her young.* The calf sucks the milk, and works up the phosphates it contains into the form of living bones, adding daily to their size and weight. Without bone our present races could not exist. It forms the skeleton to which the softer parts are attached, and by which they are supported; but the life of the animal being at an end, the function of the bone as a living thing is discharged. It falls to the earth, and new plants take up its phosphates again, to send them forward on a new mission into the stomachs of other living and growing animals. How beautiful is all this!
—*North British Review,* No. 6.

THE ANIMAL AND VEGETABLE COMPARED.

The dependence of the Animal and Vegetable kingdoms one upon the other, as well as their antagonism, may be seen at a glance by the following diagram, given in Dumas and Boussingault's work on *Organic Nature:*

An Animal is an apparatus of Combustion.	A Vegetable is an apparatus of Reduction.
Burns Carbon,	*Reduces* Carbon,
Hydrogen,	Hydrogen,
Ammonium.	Ammonium.
Exhales Carbonic Acid,	*Fixes* Carbonic Acid,
Water,	Water,
Oxide of Ammonium,	Oxide of Ammonium,
Azote.	Azote.

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* A single milch cow removes from the soil every year in its milk and annual calf what is equivalent to fifty pounds of bone-dust. This must, after a time, affect the herbage, and through it the milk of the cow and the growth of the calf. To add bone to the calf, therefore, bone-dust must be added. How curious is this!

Consumes Oxygen,	*Produces* Oxygen,
Protein,	Protein,
Fats,	Fats,
Starch,	Starch,
Sugar,	Sugar,
Gum.	Gum.
Produces Heat,	*Absorbs* Heat.
Electricity.	*Abstracts* Electricity.
Restores its elements to the air or earth.	*Derives* its elements from the a or from the earth.
Transforms organised matters into *mineral* matters.	*Transforms mineral* matters int *organic* matters.

LIFE OF THE PLANT AND THE ANIMAL.

Vegetable food contains a large proportion of starch o gum, while in the body of the Animal these substances ar wholly wanting. What becomes of the starch when eaten Why does it exist so abundantly in plants? What purpos does it serve in the animal economy? Again, all animal breathe. They inhale atmospheric air, containing one two thousand-five-hundredth part of carbonic acid; and they exhale an air containing from one to four or five *hundredth* part of the same gas. In other words, the living animal is constantly discharging carbon into the air, in the form of carboni acid. Whence is this carbon derived? What part of the foo supplies it?

The starch and sugar of the food supply the carbon fo respiration. The leaves of plants take in carbon from the air in the form of carbonic acid, that it may be converted into th starch and other analagous compounds of which their substanc consists. The digestive organs of animals undo the work o the leaves, and their lungs return the same carbon to the air in the same gaseous form of carbonic acid. That which enter the stomach in the form of starch escapes from the lungs in the form of carbonic acid and watery vapour. Thus, in another way, are animal and vegetable life connected, and again they play as it were into each other's hands. And it is beautiful to consider, that while the plant and the animal appear thus to be working contrary to each other, they are in reality producing each what is necessary to the existence of the other, and perform each its allotted part in maintaining the existing balance or stability of things. The round of animal and vegetable life may be regarded as a little episode in the history of nature. The system of the inanimate universe is complete of itself. The dead matter of the globe is comparatively little affected by the existence of life. A small portion of it is, for a time, worked up into vegetable and animal forms, and then returns again to the earth as it was. But what a beauty, though transient, does this poetry of life impart to the face of nature, clothing it with verdure, and peopling it with moving and graceful forms! What a broad field has it afforded for the exercise of the Creator's skill and bounty! Again, all the four classes of substances contained in vegetables appear equally important to the animal. With none of them can it safely dispense. The starch is necessary to supply the wants, so to speak, of the respiration; the gluten to build up the substance of the muscles; the fat to lubricate the joints, to round off the extremities of the bones, to fill up the cellular tissue, and to enable the muscles to play freely among each other; while the saline and earthy constituents of the plant yield the salts of the blood and other animal fluids, and the earthy phosphates and carbonates of the bones.—*Edinburgh Review*, No. 163.

SELECTIVE POWER OF ORGANISMS.

Both Plants and Animals (says Dr. George Wilson, who has beautifully illustrated this subject) are found to reject substances which are in abundance about them, and to appropriate others which are scantily provided by nature and can only be very slowly accumulated, even in favourable circumstances. A land plant, for example, finds in the soil which supports it much of the earth or oxide *alumina*, and very little of the alkalies potash and soda; yet it totally refuses to take any of the alumina, while it untiringly searches for and absorbs the alkalies, or dies if it cannot find them. A graminivorous animal finds in its food much silica, yet, with the exception of very little in the hair, and mere traces elsewhere, silica is absent from all its structures. On the other hand, it finds in its food very little phosphate of lime, but it appropriates the whole of it, expending it on the nutrition of every tissue, but especially in constructing its bones.

If we had the means of comparing the weight of an elephant's tusk (say of 150lbs.) with the tons of vegetable matter which the animal had to devour, and the hundredweights of silica which it had to reject, before it obtained a sufficient amount of phosphate of lime to form the ivory of a single tooth, we should have a startling proof that there is no necessary connection between the quantity of raw material offered to an organism and the quantity of that material appropriated by it. In every botanic garden we see plants requiring very different kinds of food growing side by side, and living on the same soil, from which each plant selects for itself exactly what it requires.

A still more striking example of selective action is afforded by the plants and animals which simultaneously develop themselves from the same medium, such as the sea. In any rock pool, when the tide is out, and in every thriving drawing-roo aquarium, one may find the graceful plants which we call sea weeds sipping from the mingled waters their daily fractiona dose of iodine; housed sea-snails sucking from it carbonate c lime from their shells; restless fishes extracting from it phosphate of lime to strengthen their bones; and lazy-like sponge dipping successfully into it for silica to distend the mouths o their filters.

Thus no creature is a fortuitous course of atoms. Each i as definite and constant in its chemical composition as it is i its mechanical structure or its external form. A bird does no more certainly in successive generations instinctively build it nest in the same way than, from the first moment of its embryonic life, it unconsciously builds its own body out of th same materials, gathering lime to its bones, iron to its blood and silica to its feathers.

In this way, through unnumbered centuries, each tribe o organisms has from the period of its creation followed in it structural development a chemical formula of composition, which in the same species is constant, within narrow limits, for every one of its members; so that each plant and anima has a chemical as well as an anatomical individuality.—*O Chemical Final Causes; Edinburgh Essays*, 1856.

USE OF PLANTS IN THE ECONOMY OF NATURE.

That the office of plants in the economy of the world is not so much to purify the air for animals as to supply them with nourishment, may be argued from the nature of the operation in which oxygen gas is liberated by vegetables. Plants take carbonic acid, water, &c. from the air, and decompose them, giving back to the atmosphere a part of the oxygen; while they transform the rest of the materials into vegetable fabric, or into vegetable products (mostly the prepared materials of vegetable fabric). The raw materials used contain more oxygen than the vegetable matter produced from them does. The surplus oxygen has to be eliminated, and is therefore given off in a free state, which appears to be the essential thing here;—the formation of vegetable fabric, or of organic matter, by which alone the plant can grow, form its parts, and continue to exist; or the evolution of the oxygen gas necessarily separated in the process, and which has to be got rid of.

SERVICES OF NITROGEN TO PLANTS.

There are almost countless compounds contained in nitrogen which are capable of being dissolved by water. Some of these descend from the air with the falling rain, some exist in the waters of our springs, some in the manures we add to the land, and some are formed during the decay of the vegetable matter in the soil. These enter into the roots, and no doubt supply a variable proportion both of carbon and nitrogen to the growing plant. And lastly, over the whole surface of the globe, wherever animal and vegetable substances are undergoing slow decomposition, there is a constant tendency to the production of nitric acid ; and in the air, whenever the lightning flashes, it is formed in minute quantity from the elements of the air itself. We cannot tell how much of this acid is continually produced in nature, but it must be very great, and it may safely, we think, be regarded, in the general vegetation of the globe, as one of the main forms of combination in which nitrogen enters into the circulation of living plants.—*Edinburgh Review*, No. 163.

Another writer observes : " We may say that the nitrogenous constituents of plants embody a high degree of force, which is destined ultimately to manifest itself in the sensible motions of animals. And it is a curious confirmation of this view, that if these substances pass into decomposition without being organised into muscle, they set free a large amount of chemical force ; all those *ferments* which have so remarkable a power of exciting chemical changes in other compounds, being members of this group."—*National Review*, No. 8

SILICEOUS EPIDERMIS OF PLANTS.

Sir Humphry Davy's first scientific discovery was the detection of siliceous earth in the epidermis of the cannæ, reeds, and grasses. A child had accidentally noticed the emission of a faint light when two pieces of bonnet-cane were rubbed together. On examining the fact, Davy ascertained that on striking the pieces together vivid sparks were produced, similar to those emitted by the collision of flint and steel. Davy observes of this very beautiful discovery, in *Lectures on Agricultural Chemistry*, that " the siliceous epidermis serves as a support, protects the bark from the action of insects, and serves to perform a part in the economy of these feeble vegetable tribes similar to that performed in the animal kingdom by the shell of the crustaceous insects."—*Weld's History of the Royal Society.*

Chemistry of Food.

VALUE OF NITROGEN.

The nutritive properties of Nitrogen have been greatly overrated. Magendie says: "It is true that alimentary substances which contain little or no nitrogen are not nutritive; but to conclude, as is often done, that the proportion of nitrogen contained in one element gives exactly its nutritive power, is to greatly exceed the truth deduced from the experiments which have been made on this point of physiology. Many highly nitrogenous substances are not nutritious."

HOW ANIMALS GROW FAT.

Liebig, failing to discover sufficient oily matter in the food consumed by animals to account for their fat, maintained that this substance, which merely consists of drops of oil surrounded by a delicate animal membrane, in most instances resulted from the changing in the system of starch and sugar into oil. It was difficult to prove this, however necessary the inference; but at last an experiment of Milne-Edwards set the matter at rest. He confined some bees in a glass vessel, and gave them only sugar to eat. In the course of a few days, although they had not increased or decreased in weight, they had consumed a quantity of the sugar, and had formed a large quantity of wax; thus proving that the bees must have formed the wax from the sugar. The power possessed by the animal system of converting sugar into fat seems perfectly analogous with this in the bee of converting sugar into wax.

WHAT IS THE WORTH OF GELATINE?

In the animal body is found a substance called Gelatine, which is to its existence what cellulose is in the vegetable kingdom. Although often taken into the system with animal food, especially in soups and jellies, from experiments made in France and Belgium there appears to be no evidence to show that Gelatine is used in forming any of the proteinaceous tissues of the body; at the same time it is not improbable that the Gelatine may be appropriated for renewing the gelatinous portions of the tissues, which are very extensive in the animal body. Hence, although Gelatine is not nutritious in the sense of nourishing the actively vital parts of the body, it may assist in keeping up certain parts of the fabric. It need not, then, be rejected from our food; but it cannot be too widely known, that, as the basis of soups and jellies, it may be administered under the supposition of being nutritious, and thus lead, if used alone in diet, to disastrous results.

HOW THE BODY IS NOURISHED BY FOOD.

The food consumed by man produces two, and only two, effects necessary to his existence. These are, first, to supply him with that animal heat without which the functions of life would stop; and secondly, to repair the waste constantly taking place in his tissues, that is, in the mechanism of his frame. For each of these separate purposes there is a separate food. The temperature of our body is kept up by substances which contain no nitrogen, and are called non-azotised; the incipient decay in our organism is repaired by what are known as azotised substances, in which nitrogen is always found. In the former case the carbon of non-azotised food combines with the oxygen we take in, and gives rise to that internal combustion by which our animal heat is renewed. In the latter case, nitrogen having little affinity for oxygen,* the nitrogenous or azotised food is as it were guarded against combustion, and being thus preserved, is able to perform its duty of repairing the tissues, and supplying those losses which the human organism constantly suffers in the wear and tear of daily life.

VEGETABLE AND ANIMAL FOOD.

As a sect has arisen of persons who deny the propriety of man's taking animal food, it may be well to examine the evidence on which his claim to be regarded as a flesh animal rests. We shall dismiss the sentimental objection that life ought not to be taken as unworthy of serious refutation, as every one must feel that for carnivorous animals to prey upon lower animals is a natural law.

First, the experience of the races and nations of men who partake of animal food is decidedly in its favour. Amongst the northern and European nations this practice is universal; and it is precisely among these people that we see the greatest amount of physical power and moral and intellectual development existing; whilst those individuals who partake most largely or exclusively of a vegetable diet are alik physically, intellectually, and morally degraded. Again, among thos classes who get the least animal food, as also in those public establis ments where meat is only sparingly allowed, mortality is greatest, an disease is most rife. The disease most commonly generated by an excl sively vegetable diet is scrofula, and when traceable to this cause, th most speedy remedy is the addition of animal food to the diet. An there is no surgeon or physician connected with the great medical ch rities of this country but has, unfortunately, ample opportunities witnessing the ill effects of a vegetable diet, and the benefit in suc cases of the administration of animal food.

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* "Of all the elements of the animal body, nitrogen has the feeblest attraction for oxygen; and what is still more remarkable, it deprives all combustible elements with which it combines, to a greater or less extent, of the power of combining with oxygen, that is, of undergoing combustion."—*Liebig's Familiar Letters on Chemistry.*

It has also been found, not alone as a matter of general personal e perience, but by direct experiment, that animal food is more digestib than vegetable food; as in the case of St. Martin, where Dr. Beaumon through a gun-shot wound never healed, placed various kinds of foo in the stomach, and was thus enabled to ascertain how long each r quired to digest; and it was found that the flesh of animals was muc more digestible than any of the more nutritious forms of vegetable foo as bread, and the preparations of flour. (*See ante*, p. 157.)

To this evidence may be added that on examination of th organs in man, it will be found that they are a true mixture c those of the vegetable-feeding and carnivorous animals. Hi teeth are partly adapted for grinding, whilst some of them ar supplied with the sharp projections which are characteristic c the carnivora, thus evidently adapting them for the mastica tion of both vegetable and animal food. A slight lateral move ment of the lower jaw with the up-and-down action is expres sive of the subserviency of his structure to a mixed diet. I the stomach also we find indications of the same intermediat position in its structure; and the same conclusion is force upon us, that it is part of the apparatus of an animal intende for subsisting upon a diet composed of animal and vegetabl substances.—*Abridged from Dr. Lankester's Letters on Diet.*

NUTRIMENT IN APPLES.

Chemical researches by Mr. J. H. Salisbury, of Albany, show that good varieties of the Apple are richer in those bodies whic strictly go to nourish the system than potatoes are; or, i other words, to form muscle, brain, nerve, and, in short, assis in sustaining and building up the organic part of all the tissue of the animal body.

HOW TO MAKE BREAD OUT OF WOOD.

Dr. Prout has clearly proved that all the chief alimentar matters employed by man may be reduced to three classes, viz. saccharine, oily, and albuminous substances, the most perfec specimens of which are respectively sugar, butter, and the white of eggs. The saccharine principle includes the vegetables, comprehending all those substances, whatever thei sensible properties may be, into the composition of which hydrogen and oxygen enter in the proportion in which they form water,—for example, the fibre of wood, which chemists call *lignine*, that is, the nutritive property of the woody fibre; and by means of skilful manipulation, Professor Auterith of Tubingen, in 1834, succeeded in making a *tolerably good quartern-loaf out of a deal board.* First, every thing that was soluble in water was removed by maceration and boiling; the wood was then reduced to fibres, dried in an oven, and ground as corn, when it had the taste and smell of corn-flour. Water and the sour leaven of corn-flour were then added, to make a spongy bread, which, being baked, had much crust and a much better taste than what in times of scarcity is prepared from bran and husks of corn. Wood-flour also, boiled in water, forms a nutritious jelly; the Professor also ate it in the form of gruel or soup, dumplings, and pancakes, which were palatable and wholesome.

Professor Brande, in his *Lectures*, thus records an analogous result: "Gum and sugar (grape variety) may be obtained by the action of sulphuric acid on woody fibre. *Bread* has also been made of this substance; indeed, before me is a specimen of such bread imported from Sweden. Seeing the close relation between the composition of starch and lignine, the conversion of the latter into bread does not appear so remarkable. I cannot say much, however, in favour of the bread; indeed, the quality of all such specimens from a similar source which have come under my notice has been very poor."

HOW BREAD BECOMES STALE.

In a discussion by the French Academy respecting the grave yet apparently simple question, why Bread becomes stale, M. Boussingault has laid down that staleness is not, as is generally supposed, caused by the proportion of water diminishing; but arises from a molecular state, which manifests itself during the cooling, becomes afterwards developed, and persists as long as the temperature does not exceed a certain limit. M. Thénard maintains that staleness is caused by bread being a hydrate which heat softens, but to which a lower temperature gives more consistency.

VALUE OF RICE AS FOOD.

From the earliest period the most general food in India has been rice, which is the most nutritive of all the cerealia, contains an enormous proportion of starch (from 83·8 to 85·07 per cent), and yields to the labourer an average return of at least sixty-fold.

IMPROVED BUTTER-MAKING.

It has been ascertained by experiment in America, that if at the exact moment when the butter begins to separate from the cream, more cream is gradually added, the churn continuing to be briskly worked, the effect will be magical, and the yield of butter immediate. If, however, the fresh cream be poured in too fast, it will stop the process; and it will not answer to let the agitation cease for an instant.

WHAT IS THE WORTH OF CHEESE?

Although casein as dissolved in milk is very digestible, it becomes, when separated and known by the name of cheese, very indigestible. When milk is deprived of its butter, and the pure casein made into cheese, as is the case with some English cheeses (those from Suffolk for example), it becomes so hard as scarcely to be digestible. But in most cases the casein is curdled with the butter, and a large percentage of this substance is found in all good cheeses.

PRESERVATION OF FOOD.

That meat can be preserved at temperatures below the freezing-point is well known, of which fact the frozen markets of St. Petersburg afford an example; but the most remarkable instance of preservation by frost is that of the Siberian mammoth, which is supposed to have been buried under the ice several thousands of years, and when first exposed from its icy covering the flesh was quite fresh, and was eaten by dogs. The effect of exposure to air is to decompose by the combination of the oxygen of the atmosphere with the complicated compounds of animal organisation, and that effect is increased by the presence of moisture. It is a common opinion that the light of the moon facilitates decomposition; the foundation of which notion may be traced to the circumstance that on clear moonlight nights there is a greater deposition of dew than under a cloudy sky.

Boiling checks fermentation in organic substances, by which means, the oxygen of the atmosphere being excluded, meats are preserved for long voyages; "certainly one of the most important contributions to the practical benefit of mankind ever made by science, and for this we are indebted to Gay-Lussac."—*Liebig.*

The Laboratory.

The Laboratory of the Alchemists must be sought in the backgrounds of the pictures of the old painters, who have so vividly portrayed that race of inventors. The figure in the Frontispiece to the present volume is from a work of this class, in the Orleans collection, painted by David Teniers in the 17th century.

Three distinguished philosophers of the 17th century are recorded as having cheered their hours of captivity or retirement from the strife of war in the more genial pursuits of the laboratory. Sir Walter Raleigh passed the early years of his imprisonment in the Tower of London, as we shall presently more fully describe. The Marquis of Worcester wrote a portion of his *Century of Inventions* whilst confined in the same gloomy fortress. It is said that he was preparing some food in his apartment, when the cover of the vessel, having been closely fitted, was, by the expansion of the steam, suddenly forced off, and driven up the chimney. This circumstance, attracting the Marquis's attention, led him to a train of thought which terminated in the completion of an invention, which he denominated a "Water-commanding Engine;" and when Cosmo de' Medici, Grand-Duke of Tuscany, visited England in 1656 (at which time the Marquis was a close prisoner in the Tower), his engine was exhibited at Lambeth, as recorded in the Grand-Duke's Diary.

Prince Rupert, among his chemical inventions, formed the composition now called Prince's Metal, of which candlesticks and small kitchen pestles and mortars are made: this is an alloy of copper and zinc, which contains more copper than brass does, and is prepared by adding this metal to the alloy. To the list of the Prince's inventions must be added a mode of rendering black-lead fusible, and re-changing it into its original state. To him also has been attributed the toy that bears his name as "Rupert's Drop;" that curious bubble of glass which has long amused children and puzzled philosophers.

The Prince also discovered a method of boring guns, which was afterwards carried into execution in Romney Marsh by a speculator; but some secret contrivance of annealing the metal was not understood except by Rupert, and the matter died with him. His mode of tempering the Kirby fish-hooks was amongst his lesser discoveries.

The Prince also built an experimental glass-house adjoining Chelsea College, which proved a great hindrance to the letting of the college and lands, when Sir Jonas More interfered on behalf of the Royal Society, and so the nuisance was abated.

After the Restoration, Prince Rupert, who had been appointed by Charles II. Governor of Windsor Castle, had the Keep, or Round Tower, as his official residence; and here he fitted up a laboratory, with a forge and implements for experimenting in his favourite science, metallurgic chemistry.

In the account of Sir Isaac Newton's college-life at Cambridge, we find some interesting particulars of his love of experiments in chemistry and pharmacy. His hair turned gray at the age of thirty, which he jocosely attributed to the great number of experiments he made with quicksilver, "as if from hence he took so soon that colour." He suspected himself to be inclined to consumption, and made for his own use Leucatello's Balsam, from the following recipe in his own hand:

> Put Venus turpentine one pound into a pint of the best damask rose-water; beat these together till it look white, then take four ounces of bees'-wax, red sanders half an ounce, oil of olives of the best a pint, one ounce of the oil of St. John's wort, and half a pint of sack. Set it (the sack) on the fire in a new pipkin, add to it the oil and wax, let it stand on a soft fire where it must not boil, but melt it till it be scalding hot. Then take it off. When it is cold, take out the cake, and scrape off the dirt from the bottom. Take out the sack, wipe the pipkin, put in the cake again, set it on the fire, let it melt together, and then put in also the turpentine and sanders; let them not boil, but be well melted and mixed together; take it off and stir it now and then till it is cold. If you would have it to take inwardly, add to it when it is off from the fire half an ounce of powder of scuchineal (cochineal), and a little natural balsam.
>
> For the measles, plague, or small-pox, a half an ounce in a little broth, take it warm, and sweat after it. And against poison and the biting of a mad dog, for the last you must dip lint, and lay it upon the wound, besides taking it inwardly. There are other virtues of it: for wind, cholic, anoint the stomach, and so for bruises.

Newton's application to his studies was intense. One of his few visitors was M. Vigani, a native of Verona, who, after having taught chemistry at Cambridge for twenty years, was appointed by the University Professor of Chemistry; and Dr. Bentley fitted up for him in Trinity College an old lumber house as an elegant chemical laboratory, in which he lectured for some years. Newton rarely went to bed till two or three o'clock, sometimes not till five or six, lying about four or five hours, especially at spring and fall of the leaf: at these times he used to employ about six weeks in his laboratory, the fire scarcely going out either night or day, he sitting up one night, and his assistant the other, till he had finished his chemical experiments, "in the performances of which he was most accurate, strict, exact."

"He was very curious in his garden, which was never out of order, in which he would at some seldome time take a short walk or two, not enduring to see a weed in it. On the left end of the garden was his elaboratory, near the east end of the chapel, where he at these set times employed himself in with a great deal of satisfaction and delight."*

We have no special account of the Laboratory of the Royal Society. The Museum was commenced in 1665; then was "the collecting a repository, the setting up a chemical laboratory, a mechanical operatory, an astronomical observatory, and an optick chamber; next year Evelyn presented the table of veins, arteries, and nerves, which he had made 'out of the natural human bodies,' in Italy." Sir R. Moray presented "the stones taken out of Lord Balcarras's heart, in a silver box;" and "a bottle full of stag's tears." Hooke gave "a petrified fish, the skin of an antelope which died in St. James's Park, a petrified fœtus," and other rarities. In 1681, when Dr. Grew published his curious catalogue, the museum contained several thousand specimens of zoological subjects and foreign curiosities: among the eighty-three contributors are Prince Rupert, the Duke of Norfolk, Boyle, Evelyn, Hooke, Pepys, &c.

The following list from the catalogue of the articles in the museum or repository of the society, when located at Gresham College, *circ.* 1708, will give some idea of the chemical rarities of that period.†

Things relating to Chymistry and other parts of Natural Philosophy.

The Oyl, Spirit, Volatile and fixed Salts both of the Serous and Gummous parts of Humane Blood, and that of an Ox.

The Oyl of Tobacco: One or two drops of it put on a Cat's Tongue killed her in less than a minute before the R. Society. In Lint held between the teeth of those that smoak gives ease or cures the Tooth-ache, but apt to make those sick who do not take Tobacco. Also Oyls of Lawang Bark, Camphire, Mace, and several Salts. Sal-ammoniack sublimated, also the Spirit thereof.

A Phosphorus (Hermetick), which is a mix'd matter, and being exposed about half a minute to the Sun, Day-light, or Candle, or Fire, will shine in the dark for some minutes: this made by Dr. Slare. Mr. Isaac experienced that if he exposed it to the light a little before Sun-rise, it presented a bright rosy hue, and advances in fiery colour as the Sun approaches the Meridian, and after Sun-set declines to a pale wan colour.

Instruments relating to Natural Philosophy.

An Air-pump (contrived by the Honourable R. Boyle Esq.), an Engine to exhaust the Air out of any vessel.

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[*] See the account of Newton's Rooms and Laboratory at Cambridge in *Curiosities of Science*, First Series, pp. 7, 8.

[†] Hatton's *New View of London*, 1708.

The Condensing Engine, whereby much air is crowded into a sma room.

A Weather-Cock, by Sir Chr. Wren, augmented by Mr. R. Hook.

An Instrument whereby the quantity of Rain that falls in any tim on any piece of ground is measured, contrived by Sir Christ. Wren.

The Model of an Instrument to fetch earth and other bodies fro the bottom of the sea, contrived by Dr. Hook.

A Lamp Furnace (by the same Gent.), designed for the hatchin of Eggs, in order to observe the process of generation; as also digestin of Liquors. Also by the same Author, a pair of Semi-cylindrical Lamp designed for poising the Liquor which is to feed the flame, to secur that it never dart the Flame, and also to keep it of equal strength.

The Model of an Eye, in which the Humors are represented b glasses of an answerable figure.

A Burning Glass, ½ a foot diameter.

Another, *i.e.* two thin concave glasses set together, and so to be fille up with water when used; conceived and given by Bishop Wilkins.

A large Microscope with three glasses fitted for all manner positions: it magnifies to 100 times the area's appearance to the Eye also, a lesser.

An Otocoustick to help the Hearing, given by Bishop Wilkins; this of ivory—there is another of copper, funnelled and bellyed in the middle a third of tin, conical within it: the best is the first.

A pair of Hydrostatick Scales, used to examine the specific gravit of bodies, &c.

A Box of Anatomick Instruments, viz. Saws, Knives, Chisel Forceps, Laver, Tenter, Syringe, Pipes, Probes, and Needles.

In 1710, the Society removed to a house in Crane-court Fleet Street, "being in the middle of the town, and out noise;" and here they established their library and museum In 1782, they removed to New Somerset House, and tran ferred most of their older curiosities to the British Museum.

The laboratory of the London Institution, in the rear of th main building, erected in 1819, was designed by W. H. Pepy F.R.S.: the apparatus in pneumatics, hydrostatics, electricit and magnetism, are very perfect; but the great battery of 200 double plates, 200 feet square, with which Sir Humphry Dav experimented, has long been destroyed.

The laboratory of the Royal Institution, "the workshop the Royal Society," in the basement of the building, wa originally fitted up on a scale of magnitude and completenes not before attempted in this country. Here is the vast ap paratus with which Sir Humphry Davy discovered the com position of the fixed alkalies. The apparatus is of immens power, and consists of 2000 separate parts, each composed o ten double plates, and each plate containing 32 square inches the number of double plates being 2000, and the whole surfac 128,000 square inches.

In 1802, Davy began his brilliant scientific career at the Royal Insti tution, where he remained till 1812; here he constructed his grea voltaic battery, and commenced the mineralogical collection now in th

Museum. His lectures were often attended by 1000 persons: his youth, his simplicity, his natural eloquence, his chemical knowledge, his happy illustrations and well-conducted experiments, and the auspicious state of science, ensured Davy great and instant success.

The enthusiastic admiration with which he was hailed can hardly be imagined now. Not only men of the highest rank,—men of science, men of letters, and men of trade,—but women of fashion and blue-stockings, old and young, pressed into the theatre of the Institution to cover him with applause. His greatest labours were his discovery of the decomposition of the fixed alkalies, and the reëstablishment of the simple nature of chlorine: his other researches were the investigation of astringent vegetables, in connection with the art of tanning; the analysis of rocks and minerals, in connection with geology; the comprehensive subject of agricultural chemistry; and galvanism and electro-chemical science. He was also an early but unsuccessful experimenter in the photographic art.

Of the lazy conservative spirit and ludicrous indolence in science, which at this time attempted to hoodwink the public, a quaint instance is recorded of a worthy professor of chemistry at Aberdeen. He had allowed some years to pass over Davy's brilliant discovery of potassium and its congeneric metals without a word about them in his lectures. At length the learned doctor was concussed by his colleagues on the subject, and he condescended to notice it. "Both potash and soda are now said to be metallic oxides," said he; "the oxides, in fact, of two metals, called potassium and sodium by the discoverer of them, one Davy in London, a verra troublesome person in chemistry."*

Davy first communicated his discovery of the Safety-Lamp to the Royal Society in 1815. This was followed by a series of papers, crowned by that read on the 11th of January 1816, when the principle of the Safety-Lamp was announced, and Sir Humphry presented to the Society a model made by his own hands, which is to this day preserved in the collection of the Royal Society at Burlington House.

The requisites for the proper arrangement of, and the necessary instruments for, a laboratory may be seen at length in Dr. Faraday's *Chemical Manipulation;* or in Dr. Lardner's *Chemistry for Schools.*

SIR WALTER RALEIGH A CHEMIST.

Sir Walter Raleigh appears to have exercised, to a considerable extent, the powers of his cultivated mind in order to cheer the gloom of his long imprisonment in the Tower of London. The first few years he devoted to the pursuits of chemistry. In a letter from Sir William Wade, Lieutenant of the Tower, dated 1605, we are told that "Sir Walter Raleigh hath like access (with Cobham) of divers to him; the door of his chamber being always open all the day to the garden, which, indeed, is the only garden the lieutenant hath. And in the garden he hath converted a little hen-house to a still-house, where he doth spend his time all the day in distillations." One of these results we find thus recorded in the State-Papers edited by Mrs. Everett Green :

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* From *Stories of Inventors and Discoverers in Science and the Useful Arts.* 1859.

"29 Sept. 1608.—This day Sir W. R. fell to discursing to me of the wonders he had done for the benefitt of the kingdom, how much he had spent for the service thereof, in discoveryes, &c., and after fell to tell me of his inventing the means to mak salt water sweet by furnaces of coper in the forecastle ; and distilling of the salt water as it wer by a buket putting in a pipe att once, and within a quarter of an hour it will run lyk a spiggott, so that he hath by that distilled water given 240 men every day quarts a peece and the water as sweet as milk. From that he fell to telling me upon my questions the cause of the saltness of the sea water by mountains of salt in most places and salt-peeter upon euery rock and cliff contrary to Aristotle, and that the cause of the greeness of all things that grows out of the erth is by the vitriol that is in the erth which is the salt of the erth, for lett a man with water gett all the salt out of erth, ther will nothing grow ther."

Raleigh's prison-lodging is thought to have been in the second and third stories of the Beauchamp Tower. He devoted some time to medical chemistry ; and here he prepared his celebrated Cordial. During the last illness of Henry Prince of Wales (to whom Raleigh was strongly attached), the Queen applied to Sir Walter for some of his cordial, the good effects of which she had herself experienced. Raleigh, in a letter of condolence, hazarded his belief that his cordial "would certainly cure the prince, or any other, of a fever, except in case of poison."

Raleigh's Cordial was held in such high reputation in the reign of Charles II. that a treatise on the preparation was then written, under the auspices of that monarch. It was entitled *Discours sur le Grand Cordial de Sir Walter Raleigh*, and was published in 1665. The original recipe is given by the author, Le Febure ; but Sir Kenelm Digby and Sir Alexander Fraser introduced other ingredients. Evelyn, in his Diary, under the date 1662, says : "I accompanied his Majesty to Monsieur le Febure, his chemist (and who had formerly been my master in Paris), to see his accurate preparation for the composing Sir Walter Raleigh's rare cordial. He made a learned discourse before his Majesty, in French, on each ingredient." Raleigh appears to have kept the preparation of his cordial a secret during his life. The formula is simplified in the *London Pharmacopœia* under the name of "Aromatic Confection :" it consists of zedoary and saffron, distilled water, compound powder of crabs' claws, cinnamon, nutmegs, and cloves, smaller cardamon seeds, and double refined sugar, made into a confection.

DAVY, WOLLASTON, AND JAMESON, IN THE LABORATORY.

The change in the practice of the Royal Society with respect to their Laboratory experiments was thus explained by Sir Humphry Davy in his Address on taking the President's chair in 1820,—within a few years of his apprenticeship to an apothecary, when his means were so humble that he was unable to purchase apparatus for philosophical experiments.

> In the early part of our establishment (said the President), when apparatus was procured with difficulty, when the greatest philosophers were obliged to labour with their own hands to frame their instruments, it was found expedient to keep in the rooms of the Society a collection of all such machines as were likely to be useful in the progress of experimental knowledge; and curators and operators were employed, by whom many capital experiments were made under the eyes of the Society. But since the improvement of the mechanical and chemical arts has afforded great facilities as to the means of carrying on experimental research, the Transactions of the Fellows recorded by the Society have, with some few exceptions, been performed in their own laboratories, and at their own expense. It is, however, possible that experiments of great importance, requiring funds which few individuals can command, may be suggested; and it is to be hoped that on such occasions the proposers will not fail to recur to the Society.

Sir Humphry next refers to "grand and expensive apparatus" then in public establishments, the advantage of which was becoming available.

Yet such costly means were not indispensable for the study of chemistry, as the experience of its distinguished professors shows. Dr. Wollaston's knowledge was more varied, and his taste less exclusive, than any other philosopher of his time, except Mr. Cavendish; but optics and chemistry are the two sciences for which we are under the greatest obligations to him. He had a peculiar turn for contriving pieces of apparatus for scientific purposes. By means of his reflective goniometer crystallography has acquired a great degree of perfection; and his sliding-rule for chemical equivalents furnishes a ready mode for calculating the proportions of one substance necessary to decompose a given weight of another.

Dr. Wollaston was accustomed to carry on his experiments in the greatest seclusion, and with very few instruments. His laboratory was sealed to even his most intimate friends. Dr. Paris relates that a foreigner once called on Wollaston with letters of introduction, and expressed an anxious desire to see his laboratory. "Certainly," he replied, and immediately produced a small tray containing some glass tubes, a blowpipe, two or three watch-glasses, a slip of platinum, and a few test-tubes. Upon another occasion, after inspecting Mr. Children's grand galvanic battery, Wollaston, within a tailor's thimble, completed a galvanic arrangement by means of which he heated platinum wire to a white heat.

Mr. Brande records that Dr. Wollaston's "uncommon ta neatness, and dexterity as an experimental chemist will nev be forgotten by those who had an opportunity of witnessing performance of any analytical operation : he practised a pec liar method of microscopic research, in which he willingly i structed those who asked his information ; and we owe to h numerous abbreviations of tedious processes, and a variety of i provements in the application of tests, which have gradua become public property, although he never could be induc to describe his manipulations in print, or to communicate to t world his happy and peculiar contrivances." Towards the cl of 1828, however, feeling his end approaching, and being p sonally unable to write accounts of such of his discoveries a inventions as he was reluctant should perish with him, he e ployed an amanuensis, and in this manner communicated so of his most valuable papers to the Royal Society. Within month of his death, he invested in the Funds 2000*l.* in the na of the Royal Society, the interest to be applied to the promoti of science.* Of this amiable philosopher Dr. Henry says :

> In chemistry Dr. Wollaston was distinguished by the extreme nice and delicacy of his observations; by the quickness and precision wi which he marked resemblances and discriminated differences ; t sagacity with which he devised experiments, and anticipated their r sults ; and the skill with which he executed the analysis of fragments new substances, often so minute as to be scarcely perceptible to ordina eyes. He was remarkable, too, for the caution with which he advanc from facts to general conclusions ; a caution, which, if it sometim prevented him from reaching at once to the most sublime truths, y rendered every step of his ascent a secure station, from which it w easy to rise to higher and more enlarged inductions.—*Elements Chemistry.*

The late Professor Jameson first submitted his ideas to t public as a mineralogist in an Essay on Gems, which he con tributed, when a young man, to Dr. Anderson's periodical, t *Bee.* At college, Jameson was very assiduous in the chemic class ; he paid especial attention to mineralogical informatio and analytical chemistry. Dr. Hope, who filled the chemical chai displayed the first oxyhydrogen blowpipe, which was constructe under Mr. Jameson's superintendence—an instrument indispensable in analytical mineralogy. Thus attending lectures, and studying the subjects lectured on, he did not consider these all that were necessary to form a chemist; he felt unless he could handle a crucible as well as name it, unless he could collect the gases as well as describe them, he was only a nominal chemist. His father, entering into his views, assigned him a suitable room for his laboratory, and fully supplied him with what apparatus it required, and allowed him necessary attendants in assisting him in his experiments. It shows the practical character of Jameson's mind to learn that when he left his own country for Freyberg in 1800, to study mineralogy and geology, under the learned and famous Werner, he worked in the mines there under the rules laid down by his master, and went through the same drudgery and the same kind of work as the common miner, by which means he acquired much valuable knowledge.

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* Dr. Wollaston died Dec. 22, 1828, of disease of the brain. In spite of seve suffering, his faculties were unclouded to the last. When he was nearly in t last agonies, one of his friends having observed loud enough for him to hear, th he was not conscious of what was passing around him, he made a sign for pe cil and paper. He then wrote down some figures, and after casting up the su returned the paper. The amount was right. We quote this anecdote from M Weld's *History of the Royal Society*, in which he notes: "It is very remarkabl that no life of Wollaston exists, although his reputation stands so high. It ha been observed, that had he been a German or a Frenchman, the want woul have been long since supplied."

Sir Humphry Davy, by way of illustrating the advantages which students of his day possessed over their predecessors, says:

> The apparatus essential to the modern chemical philosopher is much less bulky and expensive than that used by the ancients. An air-pump, an electrical machine, a voltaic battery (all of which may be upon a small scale), a blowpipe apparatus, a bellows and forge, a mercurial and water-gas apparatus, cups and basins of platinum and glass, and the common reagents of chemisty, are all that are required. All the implements absolutely necessary may be carried in a small trunk; and some of the best and most refined researches of modern chemists have been made by means of an apparatus which might with ease be contained in a small travelling carriage, and the expense of which is only a few pounds. The facility with which chemical inquiries are carried on, and the simplicity of the apparatus, offer additional reasons to those I have already given for the pursuit of this science. It is not injurious to the health: the modern chemist is not like the ancient one, who passed the greater part of his time exposed to the heat and smoke of a furnace, and the unwholesome vapours of acids and alkalies, and other menstrua, of which for a single experiment he consumed several pounds. His processes may be carried on in the drawing-room, and some of them are no less beautiful in their appearance than satisfactory in their results. It was said by an author belonging to the last century of Alchemy, that "its beginning was deceit, its progress labour, and its end beggary:" it may be said of modern chemistry that its beginning is pleasure, its progress knowledge, and its objects truth and utility.

Sir Humphry then recommends to the student patience, industry, and neatness in manipulation; accuracy and minuteness in observing and registering the phenomena which occur. A steady and a quick eye are most useful auxiliaries; but there have been very few great chemists who have preserved these advantages through life; for the business of the laboratory is often a service of danger; and the elements, like the refractory spirits of romance, though the obedient slave of t magician, yet sometimes escape the influence of his talism and endanger his person. Both the hands and eyes of othe however, may be sometimes advantageously made use of.

Liebig, speaking of the progress and development modern chemistry, thus illustrates the means and implemen employed by the chemist in his labours. Without glass, co platinum, and caoutchouc (he says), we should probably at t day have advanced only half as far as we have done. In t time of Lavoisier only a few, and those very rich persons, we able, on account of the costliness of apparatus, to make chen cal researches.

The wonderful properties of glass are well known : tra parent, hard, colourless, unchanged by acids and most otl liquids, and at certain temperatures more plastic and flexi than wax, it takes, in the hands of the chemist and in the fla of a proper lamp, the form and shape of every piece of ap ratus required for the experiments.

What precious properties are combined in cork! H little can any but chemists appreciate its value and recogn its good qualities! We might rack our brains in vain in t hope of replacing cork as the ordinary means of closing bott by any other substance whatever. Let us imagine a soft, hig elastic mass, which nature herself has impregnated with matter having properties resembling wax, tallow, and res yet dissimilar to all these, and termed *suberin*. This rend it perfectly impermeable to fluids, and in a great measure ev to gases. By means of cork we connect wide apertures with n row ones; with cork and caoutchouc we connect our vess and tubes of glass, and construct the most complicated appa tus without the aid of the brass-founder and the mechanist without screws and stop-cocks. Thus the implements of t chemist are cheaply and easily procured, immediately adap to any purpose, and readily repaired or altered.

Without platinum it would be impossible, in many cas to make the analysis of a mineral. To dissolve it, or render soluble, would destroy vessels of glass, porcelain, and all no metallic substances. Crucibles of gold and silver would m at high temperatures. But platinum is cheaper than go harder and more durable than silver, infusible at all tempe tures of our furnaces, and is left intact by acids and alkal carbonates.

To these means must be added the Balance. The great d tinction between the manner of proceeding in chemistry a natural philosophy is, that one *weighs*, the other *measur* The natural philosopher has applied his measures to nature many centuries, but only for fifty years have we attempted advance our philosophy by *weighing*. Once adopted, it put an end to the reign of Aristotle in physics. Three of his elements —air, earth, and water—are now matters of history.

Fire is found to be but the visible and otherwise perceptible indication of changes in the forms of bodies.

Lavoisier investigated the composition of the atmosphere and of water with the Balance; that incomparable instrument (says Liebig) which gives permanence to every observation, dispels all ambiguity, establishes truth, detects error, or shows us that we are in the true path. The principal problem of the succeeding generation was to determine the composition of the solid matters composing the earth.[*]

THE HONOURABLE CHARLES AND EDWARD CHARLES HOWARD.

In Sir Humphry Davy's posthumous work, *Consolations in Travel*, one of the personages in "Dialogue the Fifth—the Chemical Philosopher," observes:

> *Eubathes.*[†] I have often wondered that men of fortune and rank do not apply themselves more to philosophical pursuits: they offer a delightful and enviable road to distinction, one founded upon the blessings and benefits conferred on our fellow-creatures; they do not supply the same sources of temporary popularity as successes in the senate or at the bar; but the glory resulting from them is permanent, and independent of vulgar taste or caprice. In looking back to the history of the last five reigns in England, we find Boyles, Cavendishes, and Howards, who rendered these great names more illustrious by their scientific honours; but we may in vain search the aristocracy now for philosophers, and there are very few persons who pursue science with true dignity.

Of the first of the two members of the illustrious Howard family we possess some interesting memorials. At the Deepdene, near Dorking in Surrey, which for centuries formed a portion of the Howards' possessions, lived the Hon. Charles Howard, son of the seventh Earl of Arundel. Evelyn, in his *Diary*, describes his visit here, August 1, 1655: "I went to Dorking to see Mr. Charles Howard's amphitheatre, garden, or olitaire recess, being fifteen acres, inviron'd by a hill. He howed us divers rare plants, caves, and an elaboratory." Au- rey, who visited the place between 1672 and 1692, describes Mr. Howard as "a Christian Philosopher, who, in this iron age, ves up to that of the primitive times." Here chemistry was is favourite pursuit, "for the more commodious prosecution f which he erected laboratories; and in subterranean grots rmed for that purpose had furnaces of different kinds, the flues of which in some places are yet to be seen." Mr. Ho ard died in 1714, and was interred in a vault in Dorki Church. In the original garden at the Deepdene, affixed some old brickwork that formed part of the laboratory, placed a tablet bearing the following tribute to the Philos pher's character, by Lady Burrell:

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[*] Selected and abridged from *Familiar Letters.*

[†] The character of Eubathes bears a striking resemblance to that of Dr. Wol- ston; and there is little doubt that Davy intended it for a portraiture of his other chemist.

This votive Tablet is inscribed to the Memory of the Honourat CHARLES HOWARD, who built an Oratory and Laboratory on this spo He died at the Deepdene, 1714.

" If Worth, if Learning, should with fame be crown'd,
If to superior Talents fame be due,
Let HOWARD'S virtue consecrate the ground
Where once the fairest flowers of Science grew.

Within this calm retreat, th' illustrious Sage
Was wont his grateful orisons to pay;
Here he perus'd the legendary page,
Here gave to Chemistry the fleeting day.

Cold to Ambition, far from Courts remov'd,
Though qualified to fill the Statesman's part,
He studied Nature in the paths he lov'd,
Peace in his thoughts, and Virtue in his heart.

Soft may the breeze sigh through the ivy-boughs
That shade this humble record of his worth;
Here may the Robin undisturb'd repose,
And fragrant flow'rs adorn the hallow'd earth."

In the picturesque rearrangement of this portion of t grounds of the Deepdene, by the late Mr. Thomas Hope,* and l eldest son Mr. Henry Thomas Hope, the present possessor of t estate, it is gratifying to find that this interesting memor of genius and worth has been preserved with reverential care

The possession of the Deepdene by the Howard family te minated in 1792; so that the laboratory could scarcely ha been the scene of those important experiments by which t Hon. Edward Charles Howard, by great skill in chemistry, materially contributed to the improvement of the Sugar Man facture. He resided for some time in a large garden-hou fronting the Thames, in Surrey-street, Strand, part of the s of Arundel House and gardens; and here he may probal have experimented for his most valuable invention, now exte sively used under the name of Howard's Vacuum-pan, patent in the year 1813, being the most useful application of the fact th liquids are driven off or made to boil at lower degrees of heat wh the atmospheric pressure is lessened or removed. This valual thought occurred to Mr. Howard, who thereby removed t chief difficulties attending the evaporation of the sacchari syrup. The saving of sugar and improvement in quality this process were so great as to make the patent-right whi secured the emoluments to the inventor and others very valuab

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* At the Deepdene, Mr. Hope wrote his *Anastasius;* and Mr. B. Disraeli *Coningsby.*

Lord Brougham characterises it as a process by which more money has been made in a shorter time, and with less risk and trouble, than was ever perhaps gained from an invention; and as "the fruit of a long course of experiments, in the progress of which known philosophical principles were constantly applied, and one or two new principles ascertained." (*The Objects, Advantages, and Pleasures of Science.*)

It is a curious fact in scientific discovery that the most profitable invention that was ever patented in this or any other country accidentally arose out of an application to Government to admit sugar for agricultural purposes. The Government applied to Mr. Howard, the accomplished chemist, to try some experiments for the purpose of ascertaining if sugar could be so effectually adulterated that it could not be again converted for culinary uses. For this purpose he mixed all kinds of noxious materials with it, but the question remained whether they could be again separated, and in the experiments to ascertain this, he discovered that not only could they be separated, but that the sugar was better and purer. Out of this arose Howard's patent for sugar-refining and the use of the vacuum-pan; the annual net income of which, from licenses granted for its use, at the rate of 1*s.* per cwt., yielded in some years between 20,000*l.* and 30,000*l.* One house in London alone paid 4,000*l.* per annum.—*Mining Journal.*

Mr. Howard's claim to the discovery has, however, been disputed. The late Mr. J. C. Robertson, the originator and editor of the *Mechanics' Magazine*, quoted the above statement "simply for the purpose of distinctly contradicting it in every particular, and of stating, what probably has not been stated before, but is nevertheless incontrovertibly true, that Mr. Howard, though he did benefit immensely by the invention in question, was not the real inventor of it. The illustrious Davy was the real inventor, from whom Howard did but knowingly borrow it; and any one who doubts the truth of this assertion may apply to Mr. Children for his testimony on this point."

Nevertheless, it is strange that Davy should have referred to Mr. Howard in eulogistic terms, had he thus appropriated the vacuum invention; for Sir Humphry refers to the chemist of his own time, and not to the philosopher of the Deepdene, who died early in the previous century.

STORY OF THE BLOWPIPE.

Hitherto we have spoken but incidentally of this valuable instrument, which, until the year 1738, was used by jewellers and others in soldering metals on a small scale; whence it derives its name, in the German language, Löthrohr, from *löthen*, to solder, and *röhr*, a tube. In the above year, Antony Swab, a Swedish counsellor of mines, employed the Blowpipe for determining the metals in the ores and minerals; but this did not receive any particular attention until Cronstedt proposed his system of mineralogy, in which the arrangement is d pendent on the chemical composition of the minerals. Wi the Blowpipe, and the employment of fluxes in his exper ments, he founded a new department of chemical science.

The Blowpipe thenceforth became applied to chemical an lysis, and the determination of mineralogical species. Sweden, however, it still appears to have been studied wi the greatest success; and Gahn exceeded his predecessors the conception and execution of his experiments. As an i stance of his power of detecting metallic bodies, we are told Berzelius that he had often seen him extract from the ashes a quarter of a sheet of paper distinct portions of copper, an that too before the knowledge of the occurrence of this met in vegetables was known; and therefore before he could ha been led, from this circumstance, to suspect its presence i paper.

Gahn left no account of his researches; but, fortunately f science, accident threw him in the way of Berzelius: and th assiduity of Gahn in this study, together with the circumsta ces to which we are indebted for the preservation of his labour cannot be better told than in the words of Berzelius himsel "Gahn (says he) was never without his blowpipe, not even du ing his shortest journeys. Every new substance, or anything wit which he was not previously acquainted, was immediately sub mitted to an examination before the Blowpipe; and it was in deed an interesting sight to observe with what astonishin rapidity and certainty he was thus enabled to determine th nature of a body, which from its appearance and exterior pro perties could not have been recognised. Through this consta habit of using the Blowpipe, he was led to invent many improv ments, and to make many conveniencies, which he could ne have at hand, whether at home or abroad. He examined th action of a number of re-agents, for the purpose of finding ne methods of recognising bodies; and this he did in such detai and conducted his operations with such accuracy, that all hi results may be relied upon with the greatest confidence. Neve theless, it never occurred to him to give a written descriptio of his new or improved methods: he gave himself, however, a possible trouble to instruct all who were willing to learn, an many foreign men of science, who passed some time with him have made known his great dexterity in this subject; but n one has communicated a perfect knowledge of his methods.

"I had the good fortune (adds Berzelius), during the las ten years of the life of this, in many respects, most remarkabl man, to enjoy his most intimate acquaintance. He spare himself no trouble to communicate to me all the results o his experience, and I have consequently held it as a sacre duty to allow nothing of his experience and of his labours to be lost." Such, then, is the origin of Berzelius's treatise on the Blowpipe, the highest authority upon the subject: it was translated into English by Mr. Children, F.R.S.

We have not space to detail the phenomena presented by the chemical elements and minerals when experimented on by the Blowpipe, which, we may add, is merely a brass tube, fitted with an ivory mouth-piece, and terminated by a jet having a small aperture by which a current of air is driven across the flame of a candle. The flame so produced is very peculiar.

Among the eminent workers in the Laboratory, the alchemists of mediæval Europe at first sight seem to stand in no true historical relation with the practical chemists of the present century. The seeking for the Alkahest or Universal Solvent, the Elixir of Life, and the Philosopher's Stone, were pursuits essentially unlike the sober and attainable aims of our own positive chemistry; and the men of our own laboratories would have taken little interest in the labours they involved, had it not been for the fact that those old scholastics, chasing images they were never to seize, worked out thousands of incidental results. If they were fond idealists, if they were visionaries, they were also chemists; and it is as chemists they deserve the recognition of the world. They worked with water, they worked with fire; they digested, boiled, distilled, roasted, burned, smelted, crystallised, set a-going putrefactions and fermentations; in short, they put in operation the same sorts of processes upon the same sorts of stuff as ourselves. Following their hereditary and antique elemental ideas, they were the first discoverers of those material principles and compounds which are commonly called chemicals; and the really great men among the alchemists were the busy students of such chemical reactions as could then be brought within the reach of the experimentalist, and made no personal pretensions to the Stone.

Soon after the time of Paracelsus, the alchemical theory and the alchemical practice of genuine observation in the laboratory fell asunder. The orient *al* departed, and left chemistry to pursue its own fortunes. The ancient eastern element did not, however, at once disappear from the earth; for it retained its devotees, no longer respectable, because behind their age, till the present century. On the other hand, those who chose the path of true chemistry addicted themselves with zeal to the finding out of all sorts of new chemicals and chemical reactions. To the positive labours of the laboratory there quickly succeeded a remarkable extension of practical or concrete chemistry; and the number of solid and liquid bodies, curious for their aspects or for their properties as chemical re-agents, acids, alkalies, salts, mixts, calxes, precipitates, sublimates, essences, oils, butters, and spirits, which were brought out of nature at this period was astonishing. It is impossible, indeed, for the most positive and the least speculative of the chemists of the present day, were it even a Rose and his platinum crucible, or a Plattner with his blowpipe, to over-value the amount of plain, honest, and sufficient, though merely preliminary, work that was done between the apotheosis of alchemy and the ascension of the phlogistic chemists.—*Selected and abridged from the North British Review,* No. 35.

Chemical Manufactures.

WHAT ARE CHEMICAL INVENTIONS?

DAVY makes one of the characters in his Dialogue, "The Chemical Philosopher," thus eloquently recapitulate the invaluable benefits of applied chemistry to the arts of life.

You will allow that the rendering skins insoluble in water by combining with them the astringent principle of certain vegetables is a chemical invention, and that without leather our shoes, our carriages, our equipages would be very ill made. You will permit me to say, that the bleaching and dyeing of wool and silk, cotton and flax, are chemical processes; that the working of iron, copper, tin, and lead, and the other metals, and the combining them in different alloys, by which almost all the instruments necessary for the turner, the joiner, the stonemason, the ship-builder, and the smith are made, are chemical inventions; even the press could not have existed in any state of perfection without a metallic alloy; the combining of alkali and sand, and certain clays and flints, together, to form glass and porcelain, is a chemical process; the colours which the artist employs to frame resemblances of natural objects, or to create combinations more beautiful than ever existed in nature, are derived from chemistry. In short, in every branch of the common and fine arts, in every department of human industry, the influence of this science is felt; and we see in the fable of Prometheus taking the flame from heaven to animate his man of clay an emblem of the effects of fire in its application to chemical purposes, in creating the activity and almost the life of civil society.

PROPERTIES OF GUNPOWDER.

Upon reference to the relative proportions of ingredients in ancient Gunpowders,—for example, those given by Tartaglia, about three centuries since,—they will be found to yield powder scarcely more powerful than the composition of a squib, and altogether inapplicable to the exigencies of modern warfare. This did not arise from ignorance of better proportions; but it is conjectured that the guns were then so weak that stronger powder would have destroyed them. No doubt the proper ratio of ingredients to form good Gunpowder can be determined, *à priori*, from a consideration of chemical laws; yet it is a remarkable fact, that some time before chemistry was thus far advanced, manufacturers had, by dint of mere experience, discovered the best proportions. Modern chemistry, therefore, in this respect, can afford them no aid. The last great improvement in Gunpowder consists in what is termed "cylinder" charcoal, whereupon the resulting material acquired so much additional strength that the proportion of charges used for ordnance was in consequence reduced nearly one-third.

If Gunpowder, as now prepared, have any fault, it consists in being, for ordinary purposes, rather *too* strong. Were it desirable, its strength, by a trifling change in the manipulation, might be still further increased, without any alteration of the ingredients or their proportions: indeed, Sir William Congreve actually made some Gunpowder in this manner; but it was found to explode on percussion, besides being in other respects highly dangerous.

The enormous force of inflamed Gunpowder depends on the evolution of various gases, the volume of which, when cooled, it is easy enough to determine; but at the moment of their formation they are vastly dilated by heat, so that their actual effective volume and pressure cannot be justly ascertained. It has been pretty correctly found that a cubic inch of Gunpowder is converted by ignition into 250 cubic inches of *permanent* gases, which, according to Dr. Hutton, are increased in volume eight times at the time of their formation by the expansive influence of heat. Assuming these data to be true, and they have been tolerably well verified, confined and ignited Gunpowder will exert, at least, a force of 2000 lbs. on every square inch opposed to its action.

The proportions of the three ingredients now universally adopted in this country in the manufacture of every 100 lbs. of Gunpowder are:

Saltpetre.	77½ lbs.
Sulphur	10½ ,,
Charcoal.	16 ,,
Total . .	104

The extra 4 lbs. being allowed for waste.

The atomic composition which approaches nearest to that of Gunpowder is, 1 equivalent of nitre, 1 of sulphur, and 3 of carbon, or,

Saltpetre	74·6
Sulphur	11·9
Charcoal	13·5
	100·0

The theory of the combustion of Gunpowder is this: the sulphur accelerates deflagration and supplies heat; the nitre supplies oxygen and nitrogen gases; and the carbon, by its strong affinity for oxygen, promotes the decomposition of the nitre, combining with its oxygen so as to produce carbonic-acid gas. The sulphur melts at 226°, and under 280° forms a clear liquid of an amber colour, and below 600° it inflames. In the decomposition of Gunpowder by explosion, the sulphur combines with the base of the potash to form a solid residuum, a sulphide of potassium; whilst three equivalents of carbonic acid and one of nitrogen are the gaseous products.

Professor Bunsen, however, has found that the decomposition which occurs in an explosion is by no means so simple as was formerly supposed. Besides the usual products of carbonic acid, carbonic oxide, nitrogen, and sulphide of potassium, Bunsen shows the presence of hydrogen, oxides of nitrogen, cyanide of potassium, sulpho-cyanide of potassium, sulphate and carbonate of potash, and various other salts.

Mr. Faraday, in a paper read to the Royal Institution, dwells on the great importance of *time* in producing the effects of Gunpowder. Contrasting its action with that of fulminating mercury, or of those more fearfully explosive compounds the chlorides of nitrogen and iodine, Mr. Faraday shows, that if the explosion of Gunpowder were instantaneous, it would be useless for all its present applications. As it is, however, whenever Gunpowder is fired in the chamber of a gun, it does not arrive at the full intensity of its action until the space it occupies has been enlarged by that through which the ball has been propelled during the first moment of ignition. Its expansive force is thus brought down and kept below that which the breech of the gun can bear, whilst an accumulating, safe, and efficient momentum is communicated to the ball, producing the precise effects of gunnery.

This manageable action is contrasted by Faraday with the effect of a morsel of iodide of nitrogen put upon a plate, and exploded by being touched with the extremity of a long stick. The parts immediately in contact with the iodide were shattered, *i. e.* the end of the stick was shivered, and the spot in the plate covered by that substance was drilled as if a bullet had been fired through it; yet no tendency to lift the stick was felt by the hand, whereas the comparatively gradual action of Gunpowder lifts and projects those weaker substances, wadding and shot, which give way before it.[*]

It has been shrewdly remarked that Gunpowder was invented by a priest, and Printing by a soldier. The manufacture of Gunpowder was also improved by a Bishop of Llandaff, Dr. Watson, who, for his ingenuity, was one day twitted at Court by George III.

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[*] See "Invention of Gunpowder," *Things not generally Known*, First Series, p. 209. Few people are aware of the enormous quantity of gunpowder used for military purposes. At the siege of Ciudad Rodrigo, in January 1812, 74,978 lbs. of gunpowder were consumed in thirty hours and a half; at the storming of Badajoz, 228,830 lbs. in 104 hours, and this from the great guns only. At the first and second sieges of San Sebastian 502,110 lbs. were used; and at the siege of Saragossa the French exploded 45,000 lbs. in the mines, and threw 16,000 shells during the bombardment. One day of the war in the Crimea, the Russians in Sebastopol discharged 13,000 rounds of shot and shell, the only result of which was *three men wounded!—New Quarterly Review:*

When Watson was unanimously elected by the senate to the Professorship of Chemistry, in the University of Cambridge, in 1764, he *knew nothing of chemistry whatever;* but he did not disappoint the confidence that was felt by himself and others in his ardour, application, and quickness of comprehension. With the assistance of an operator, whom he sent for immediately from Paris, and by immuring himself in his laboratory, he, in about fourteen months, was enabled to read his first course of lectures, which were very successful. He was a Fellow of the Royal Society, and contributed many chemical papers to their *Transactions;* he also wrote and published six volumes of Chemical Essays, which were long very popular.

ANCIENT SUGAR.

Dioscorides is said to be the first writer who used the word *Saccharum*, or Sugar, which he describes as a sort of concrete honey, found upon canes in India and Arabia Felix: "it is in consistence like salt, and it is brittle between the teeth like salt." Seneca describes it also as concrete cane-juice. Pliny speaks of sugar as brought from Arabia, and better from India. "It is," he says, "honey collected from canes, like a gum, white and brittle between the teeth; the largest is the size of a hazel-nut. It is used in medicine only." Galen, in the second century, describes sugar almost identically with Dioscorides, excepting that he says nothing of its brittleness and resemblance to salt. In the seventh century, however, Paulus Ægineta specifies sugar as "the Indian salt, in colour and form like common salt, but in taste and sweetness like honey." He recommends that a piece be kept in the mouth, to moisten it, during fevers; from which it may be supposed that the sugar then known was in the form of candy.

Thus it appears that sugar was known as early as the Christian era; and that its origin was very imperfectly understood by ancient Greek and Roman writers. It is probable that the white sugar-candy of China, which has been very long celebrated for its excellence, was the Indian salt of the Roman authors.

The historians of the Crusades describe sugar-cane as met with by the Crusaders in Syria; and one of these, Albertus Agensis, about 1108, says that "sweet honeyed reeds," called *Zucra*, were found in great quantity in the meadows about Tripoli, and were sucked by the Crusaders' army. He describes the husbandmen as bruising the plant, when ripe, in mortars, and setting by the strained juice in vessels till it is concreted in the form of snow, or of white salt: this being the oldest mention extant of the process of extracting sugar from the cane; and the same author records in 1110 the capture by the Crusaders of eleven camels laden with sugar. Other authorities, however, consider sugar to have been cultivated in modern Europe antecedently to the above date, as well as imported by the Venetians, from the Levant: it was certainly imported into Venice as early as 991. The cane is supposed to have been first planted in Valencia. The manufacture, derived originally from China and India, was introduced into the western world by the Spanish and Portuguese.

Refined sugar has been used in England for four centuries; since we find Margaret Paston (in the celebrated *Paston Letters*) writing to her husband from Norwich thus: "I pray that ye will vouchsafe to send me another sugar-loaf, for my old one is done."

To the honey, grape, manna, and fruit sugars, which were the principal sweets of the ancient world, we now add the cane, maple, beet, maize, and palm sugars. We manufacture sugar also from potatoes, and other substances rich in starch; from sea-weeds gathered from the shore; even from saw-dust when an emergency arises; and we extract it from the milk of our domestic cattle. It has become to us, in consequence, almost a necessary of life. We consume it in millions of tons; we employ thousands of ships in transporting it. Millions of men spend their lives in cultivating the plants from which it is extracted, and the fiscal duties imposed upon it add largely to the revenue of nearly every established government. It may be said, therefore, to exercise a more direct and extended influence, not only over the social comfort, but over the social condition, of mankind than any other production of the vegetable kingdom, with the exception, perhaps, of cotton alone.—*J. F. W. Johnston, M.A.*

COMPOSITION OF SUGAR.

Every variety of sugar is made up of carbon, hydrogen, and oxygen, in various proportions. The one remark applies, however, to all,—that the carbon and hydrogen exist in the exact proportion to form *water;* moreover, no variety of sugar contains nitrogen: this latter fact is expressive of the purpose which sugar subserves when taken as an aliment. It is unable to contribute nitrogen to the animal economy; but it powerfully contributes to the fixation of carbon in the form of fat, besides contributing to the animal temperature by the combustion of another portion of carbon.—*Brande's Lectures.*

SUGAR MANUFACTURE.

In every case, one object is paramount, the removal of impurities. This is done through the agencies of lime-water and bullock's blood. The real use of lime-water appears to be this,—the lime forms a chemical union with various colouring matters existing in Muscovado sugar, and yields a flocculent precipitable substance, which, being subsequently enveloped in the albumen of the blood-serum, coagulated by heat, rises to the surface in a scum, and may be removed.

Perhaps no agent is so effectual as the subacetate of lead. Chemists have long been aware of this fact, but they could not separate the excess of subacetate of lead, which is poisonous, without injuring the sugar at the same time. Dr. Scoffern accomplished this result ingeniously and effectively by means of sulphurous-acid gas, which being transmitted through the leaded sugar solution by means of a forcing-pump, every portion of lead is removed. Professor Brande believes the means of extracting the last portions of lead by Dr. Scoffern's process to be infallible, and that they involve no greater amount of difficulty or skill than may be commanded by every sugar manufacturer who chooses to devote adequate attention to the subject.

The vacuum-pan, and other improvements by the Honourable Mr. Howard in the manufacture of sugar, have already been noticed (see page 182). The injurious effect of heat upon sugar might in great measure be prevented. The production of molasses in the rude colonial manufacture is chiefly the result of the high and long-continued heat applied to the cane-juice, and might be almost entirely prevented by the use of vacuum-pans ; the product of sugar being thereby greatly increased in quantity, and so far improved in quality as to become almost equal to the refined article. Indeed, it may be said, that no branch of our manufacture depends more directly upon chemical research, and the diffusion and application of chemical knowledge, than the manufacture of sugar.

The root of the Beet contains often as much as a tenth part of its weight of sugar. By squeezing out the juice, or dissolving out the sugar from the sliced root and boiling down the solution, the raw sugar is obtained. It then possesses an unpleasant flavour, derived from the beet-root; but when refined it is scarcely distinguishable from cane sugar.

At an average of 3 tons an acre of sugar and molasses, it requires upwards of 130,000 acres of rich land to produce the sugar yearly consumed in the British Islands !

Formerly, when sugar was much dearer than at present, it was extensively adulterated with an inferior description of sugar made from potato-starch by the action upon it of dilute sulphuric acid. But this adulteration has, we believe, ceased. Dr. Pereira, on inspecting an extensive manufactory at Stratford in Essex, found that the potato-sugar was used for mixing with brown sugar, and the molasses produced was consumed in an oxalic-acid manufactory. Sugar has also been extracted from diseased potatoes without the disease touching the starch.

Sugar is phosphorescent, when two pieces are rubbed together in the dark; when exposed to a high temperature, sugar undergoes decomposition, yielding various gaseous products, and leaving a large proportion of charcoal, on account of which 1-100th of a grain of sugar is capable of imparting colour to an ounce of sulphuric acid.

A detonating sugar has been obtained by means similar to the mode of preparing gun-cotton: when suddenly heated to redness, this sugar explodes like gunpowder.

HOW TO OBTAIN SUGAR FROM RAGS.

A curious and interesting experiment may be made by very slowly adding concentrated sulphuric acid to half its weight of lint, or linen cut into small shreds, triturating them in a mortar, and leaving the mixture to stand for a few hours; after which it is to be rubbed up with water, and warmed and filtered. The solution may then be neutralised with chalk, and again filtered. The gummy liquid retains lime, partly in the state of sulphate, and partly in combination with a peculiar acid, composed of the elements of sulphuric with those of the lignine, to which the name Sulpho-lignic Acid is given. If the liquid, previous to neutralisation, be boiled three or four hours, and the water replaced, acid evaporates, and the dextrine becomes entirely changed to grape sugar. Linen rags may by this means be made to furnish more than their own weight of that substance.

SUGAR AND THE TEETH.—TEETH PARASITES.

M. Larez, of France, has proved that sugar, from either cane or beet, is injurious to healthy teeth, either by immediate contact with them or by the gas developed owing to its stoppage in the stomach. If a tooth is macerated in a saturated solution of sugar, it becomes gelatinous, and its enamel opaque, spongy, and easily broken. This modification is due, not to free acid, but to a tendency of sugar to combine with the calcareous basis of the teeth.

Dr. J. H. Bowditch, of the United States, having examined with a microscope matter deposited on the teeth and gums of more than forty individuals, selected from different classes of society, and in every variety of bodily condition, in nearly every case he discovered animal and vegetable parasites in great numbers; in fact, the only persons whose mouths were found to be entirely free from these parasites cleaned their teeth four times daily, using soap once. Among the various agents applied were tobacco juice and smoke, which do not impair the vitality of the parasites; nor does chlorine tooth-wash, pulverised bark, soda, ammonia, &c. Soap, however, pure white soap, destroys the parasites instantly.

It has been asked, in *Notes and Queries, Did the Greek surgeons extract teeth?*—to which Mr. George Hayes has replied, that on one of the ornaments found in some ancient buildings in the Crimea is represented a surgeon drawing a tooth from the mouth of one of the barbarian royalties. "This," says Mr. Hayes, "I think establishes the fact that there were then peripatetic, either Egyptian or Greek, dentists, who resorted to distant countries to practise their art." It is believed this is the only representation of a surgical operation to be met with on ancient sculpture.

HOW THE BEE MAKES HONEY.

The honey is formed or naturally deposited in the nectaries of flowers, and is extracted from them by the working bees. They deposit it in their crop or honey-bag, which is an expansion of the gullet (œsophagus), and from this receptacle they disgorge it again when they return to the hive. In the interval, it is probably somewhat altered by admixture with the liquids which are secreted in the mouth and crop of the insect; so that the honey we extract from the hive may not be exactly in the same chemical condition as when it was sucked up by the bee.—*J. F. W. Johnston.*

COMPOSITION OF BELL-METAL.

This consists generally of from five to three of copper to one of tin; all alloys of this kind being technically called *bell-metal*, whatever purpose they may be used for, just as the softer alloys of eight or ten to one are called *gun-metal*, and the harder and more brittle alloy of two to one is called *speculum-metal*. Other metals and alloys have been suggested for bells: as aluminium, pure or alloyed with copper; cast steel, the iron and tin alloy called *union-metal*, and perhaps we may add glass. Now aluminium is about fifty times as dear as copper, even reckoning by bulk, and much more by weight. Steel bells are said to be harsh and disagreeable, and the same is said of union-metal. The sound of glass is very weak. Much has been said of silver in bells; but it is purely a poetical, not a chemical, ingredient of any known bell-metal, and there is no foundation whatever for the vulgar notion that it was used in old bells, nor the least reason to believe that it would do any good: silver has been put into the pot in a bell-foundry in our time without producing any particular effect; and we can determine for ourselves that a silver cup makes a worse bell than a cast-iron saucepan.

Dr. Percy has cast several small bells of different alloys, besides the iron and tin just mentioned. One of iron, 95, and antimony, 5, differs but little from that of iron and tin of the same proportions, and is clearly not so good as copper and tin. It should be mentioned that antimony is generally considered to produce an analogous effect to tin in alloys, but always to the detriment of the metal in point of tenacity and strength. Again, a bell of copper, 88·65, and phosphorus, 11·35, makes a very hard compound, capable of a fine polish, but more brittle than bell-metal, and inferior in sound even to the iron alloys. Copper, 20·14, and aluminium, 9·86, which makes the aluminium bear about the same proportion in bulk as the tin usually does, seems more promising. This alloy exceeds any bell-metal in strength and toughness, and polishes like gold; and it is superior to every thing except gold and platinum in its resistance to the tarnishing effects of the air. But this alloy will not stand for a moment against the old copper-and-tin alloys for bells. A brass bell is better than the phosphorus and aluminium alloys, though inferior to bell-metal.

M. Deville, of Paris, has cast a bell of aluminium, from a drawing of our great Westminster bell reduced to six inches diameter. He has also turned the surface, which improves the sound of small bells where the small unevennesses of casting bear a sensible proportion to the thickness of the metal. Still the sound exceeds all others in badness.

The question remains, What are the best proportions for the copper and tin alloy, so as to give the strongest, clearest, and best sound possible? They have varied from something less than three to something more than four of copper to one of tin, even disregarding the bad bells of modern times, some of which contain no more than ten per cent of tin instead of from one-fifth to one-fourth, and no less than ten per cent of zinc, lead, and iron adulteration.

From various experiments, it has been found that the best metal for the purpose is that which has the highest specific gravity of all the mixtures of copper and tin. It is clear, however, that the copper now smelted will not carry so much tin as the old copper did, without making the alloy too brittle to be safely used. It has been found that the three-to-one alloy, even melted twice over, had a conchoidal fracture like glass, and was very much more brittle than 22 to 7 twice melted, or 7 to 2 once melted; accordingly the metal used for the Westminster bells is 22 to 7 twice melted; or, reducing it for convenience of comparison to a percentage, the tin is 21·1 of the alloy (not of the copper), and the copper 75·86. This 22 to 7 mixture, or even 3½ to 1, which is probably the best proportion to use for bells made at one melting, is a much "higher" metal, as they call it, than the modern bell-founders, either English or French, generally use. Mr. E. B. Denison, M.A., the founder of the Westminster palace clock and peal bells, and the author of the paper whence most of these facts are derived, advises every person who makes a contract for bells to stipulate that they shall be rejected if they are found on analysis to contain less than 22, or, at any rate, 21 per cent of tin, or more than 2 per cent of any thing but copper and tin.

GLASS-MAKING.

Upon no branch of invention have the researches into Egyptian antiquities thrown a stronger light than upon Glass-making. Thus, the discovery of a glass bead, with the name of a Pharaoh of the eighteenth dynasty, proves glass-blowing to have been known upwards of 3200 years ago. Wilkinson found at Beni Hassan two paintings of glass-blowers at work; and from the hieroglyphics accompanying them, they are shown to have been executed 3500 years ago. The use of glass bottles is also shown by far older paintings than the above.

"Glass (says Sir Gardner Wilkinson) was applied to many uses by the Egyptians, who were always celebrated for their skill in its manufacture: natron, or subcarbonate of soda, a native production in different parts of the country, was the very substance most likely to lead to its invention, or rather to its accidental discovery; and it is far more reasonable to suppose that this would have been made where natron abounded than from a fire once accidentally lighted on the sea-shore by some Phœnicians who happened to be carrying a cargo of natron." (*The Egyptians in the time of the Pharaohs*, p. 86.)

It is a curious fact in the history of discovery, that the manufacture of Glass is unknown at Sidon, in Syria, not far from Belus, where the above accidental discovery is laid. Anciently, however, Sidon was famous for its glass articles.

The claims of glass to be ranked as a strictly chemical combination, illustrated by Faraday, will be found noticed in *Things not generally Known*, First Series, p. 211.

Although perfectly transparent itself, not one of the materials of which glass is made partakes of that quality; a combination, which may, at the period of its invention, have been as astounding as the identity of carbon and the diamond, established by the chemical philosopher of our own time.

The obtaining of achromatic (so as to remedy aberration of colour) flint-glass has long been a difficulty with the scientific maker. Mr. Apsley Pellatt, some years since, constructed a small furnace to try the principle of agitating fused flint-glass by a covered rotating pot, with one or more interior divisions; and this mode of subjecting the glass to a uniform intensity of heat and agitation destroys the striæ, or cords, without exposing the contents to the cooling effects of the atmospheric air. Mr. Pellatt maintains that there would be no difficulty in ensuring good achromatic flint-glass, could the manufacturer anticipate a fair remunerative price and demand, after having succeeded in obtaining the quality. Probably, he could only sell 600 cwt. per annum, were he to supply all the opticians in Great Britain, which, at ten times the price of ordinary flint-glass, would scarcely be remunerative. The quality of optic plate is uncertain ; and if unfit for the optician, it becomes valueless to the manufacturer for other purposes. As an affair of science and merit, especially were a Government premium offered for a uniformly certain process, which has not yet been accomplished at home or abroad, it is anticipated that English manufacturers would rival foreigners in this field of honourable competition.

"The manipulatory operations of glass-making are dissimilar to casting metals of any kind. Scarcely any advance in this department of the manufacture has been made for above two hundred years ; and the tools then used for blowing and shaping the various articles have been but little improved. There can scarcely be chemically, and in reference to the preparation of the crude materials, a manufacture of greater simplicity, or of easier management, than that of Flint-glass." *

Coke possesses one of the remarkable properties of the diamond—that of *cutting glass* so clean and perfect as to exhibit the most beautiful prismatic colours, owing to the perfection of the incision.

Malleable Glass was made in old Rome ; and in the reign of Tiberius, a Roman artist had, according to Pliny, his house demolished—according to other writers, he was beheaded—for making glass malleable. The idea of discovering the secret was only ranked second to that of the Philosopher's Stone among alchemists ; but in 1845, there is stated to have been discovered at St. Etienne in France the means of rendering glass as malleable when cold as when first drawn from the pot. The substance silicon is combined with various other substances, and can be obtained opaque or transparent as crystal ; it is described as very ductile and malleable, neither air nor acids acting upon it.

Rough Plate-Glass, not transparent, but well adapted for railway-stations and workshops, and for use in horticulture, is now made by a very simple means, patented by Mr. Hartley, of Sunderland. The sole secret consists in ladling rough glass directly on to a hot table near the melting-pot, in place of carrying it as heretofore out of the refining-pot to a cold table at some distance from the furnace. By this means rough plate-glass is now made in minutes instead of hours, or days; and in patterns stamped by the table, which becomes so hot as to keep the glass molten till stamped, and till one ladleful is added to another and imperceptibly joined to it, so as to form plates of any size. One glass-making firm is stated to have expended 25,000*l.* in vainly endeavouring to use the ladle and to draw the table close to the rough melting-pot!

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* See *Curiosities of Glass-making:* with Details of the Processes and Productions of Ancient and Modern Ornamental Glass Manufacture. With coloured Illustrations. By Apsley Pellatt. Small 4to, 1849.

Soluble Glass and *Water-Glass* are the names given to soluble Silicate of Soda, which, in contact with lime, consolidates, and is partly converted into silicate of lime. Silicate of soda is the substantial element in Ransome's artificial stone process, and other similar processes, in which a porous sandstone or limestone, being saturated with this silicate, not only consolidates, but combines with the lime, forming a compact mass of flinty hardness, and impervious to atmospheric influence. The soluble Silicate has also been employed as a protecting varnish for out-door fresco-paintings in Berlin. Mixed with lime, it forms a good cement for china and glass.

PAINTED AND STAINED GLASS.

Glass is coloured by mixing some metal with the ingredients in the melting-pot. Mysterious recipes, so recently as fifty years ago, were affected for making the coloured pot-metal. Most of the discoveries are said to have been accidentally made. The ancient glass was coloured by using gold in the pot; yet it was by chance discovered, in a German glass-house, that a beautiful red may be procured from copper, and this is now done. The existing mode of blowing ruby glass is thought to be as old as the use of coloured glass in England, which is said to date from the year 647. It has been often said that modern glass-painters cannot produce the rich ruby-red of the ancients; but this is an error: there is no difficulty in its production at the present day; but the cost of the powder (a compound containing much gold) by which it was anciently produced causes the moderns to use less expensive ingredients, except for first-rate work. Protoxide of copper is generally used, and is stated to produce a red equal to the ancient colour. (See *Things not generally Known*, First Series, p. 226.)

Professor Buckman has analysed *tessellæ* from Roman pavement found at Cirencester, and found that on scraping away the verdigris-green of a medallion of Flora, a beautiful ruby glass presented itself. An analysis showed the change from ruby to green to be due to the fact that the ruby glass had derived its colour from peroxide of copper, and that the *tessellæ* had become covered with carbonate of copper from a decomposition of their surfaces.

Yellow is the only colour that can be applied to glass as a stain upon its surface; for the colour in the pot-metal and the flashed glass in all other cases enters into actual combination with the melted materials. This yellow stain was unknown before the beginning of the 12th century, about the time of Edward I., and has ever since been much used in preference to the yellow pot-metal. It possesses this great advantage, that while all other colours are diffused over the entire piece of pot-metal glass, yellow can be applied partially, and it is the only stained glass properly so called. Silver was the material employed in this yellow stain: this discovery is attributed to Van Eyck; but it is ascribed with greater reason to Beato Giacomo da Ulmo.

White glass can be ornamented with a yellow device, and a yellow stain applied to each side of white glass produces a very rich colour. It can also be applied to blue flashed glass, making it green, or to ruby, which it turns into bright scarlet; so that the yellow stain added greatly to the resources of the ancient glass-painters.—*Abridged from a paper by Mr. G. J. French, F.S.A.*

Cobalt produces so intense a blue that a single grain of the pure oxide will give a deep tint of blue to 240 grains of glass.

The superior colours of ancient glass may be partly the result of age, as well as manufacture or method of painting. "We all know the purifying as well as the bleaching effect of light; and may we not reasonably suppose that during the lapse of ages the old glass has been permeated and saturated by floods of light, so that the colours have been chastened, purified, and exalted in brilliancy?"—*Painting popularly Explained, by T. J. Gullick, Painter, and John Timbs, F.S.A.*, p. 141.

FLAX PROCESSES.

Remarkable modifications in woody fibre have been effected by chemical treatment; as in the Cottonising processes of Claussen, and the Corrugating processes of Mercer.

On account of the difficulties of working flax in those forms of machinery employed in the manufacture of cotton, M Claussen converts flax, by a chemical process, into a state something like that of cotton. This he accomplishes by first steeping the flax in a lixivium of carbonated alkali, and subsequently in a weak acid. Now the combined agencies of these two menstrua are as follow: no sooner does the acid come in contact with the carbonated alkali, previously absorbed by the cotton fibre, than carbonic acid is liberated; which gas, exercising a pressure, bursts the filaments of the flax asunder, and reduces the material to a physical condition something like that of cotton.

Mercer's Corrugating process has for its object the strengthening of cotton tissues by corrugation of their fibres. This he accomplishes by the action of caustic alkaline lyes, which deposit their alkali in the state of chemical union with the cotton-cloth, swelling and at the same time corrugating its tissue, whilst the capacity of that tissue for the reception of colours is simultaneously increased.

It is not a little remarkable that the corrugating process should have remained for Mr. Mercer to discover. Ever since the first establishment of the cotton manufacture, a solution of soda has been employed in one stage of the operation of bleaching; but the solution, when employed with this object in view, is used hot, and this circumstance accounts for the long period during which the facts observed by Mr. Mercer, and incorporated into his new process, remained undiscovered.

If cotton be submitted to the action of a *hot* solution of soda, no combination of the alkali with the cotton fibre takes place, but a mere bleaching action results, chiefly dependent on the removal of coloured resinous matter. If, however, the same cotton fibre be subjected to the action of *cold* soda-solution, a very peculiar result ensues. Supposing the alkaline solution poured through the fabric, if the layers of cotton be sufficiently numerous, the whole of the alkali in the solution employed will be removed, and retained in combination with the fabric, imparting to it a peculiar corrugated appearance. The combination, however, is not permanent, since boiling water poured upon the tissue expels the whole of the soda. But the cotton does not return to its original state; for every equivalent of soda expelled, an equivalent of water has been taken into combination, and this combination is permanent. (*Brande's Lectures*, edited by Scoffern.)

Belfast and its neighbourhood is one of our great seats of linen manufacture. Here, in the bleaching-works, may be seen the linen steamed in wooden vats, and alternately immersed in a solution of chloride of lime mixed with carbonate of soda, and of sulphuric acid, many times, during which process the linen is violently beaten about by large wooden arms in a stream of water. It is then rubbed in a machine with a strong soap, in another it is starched; and subsequently, by long-continued thumping with beetles, the peculiar gloss is imparted to the linen.

In the vitriol-works here are prepared not only oil of vitriol, but also the chloride of soda and carbonate of lime, which are used in the bleaching process. The sulphuric acid is made in enormous leaden chambers or cisterns, where it is concentrated, and the evaporation is completed in a platinum still. Salt, and condensed hydrochloric acid, and coal, chalk, and sulphate of soda, are mixed together to form in the furnaces the "black-cake," from which the alkaline carbonate is extracted. Here also are the retorts for the evolution of chlorine gas, which, passed over lime, forms the bleaching-powder.

At the starch and glue works may be seen meal converted into starch, and rough scraps of hides and hoofs into glue and size.

WET AND DRY ROT.

Wet Rot in timber depends on a real chemical decomposition, referable to the combined agency of air and moisture, exercised at certain temperatures. Dry Rot is attributable to the growth of certain fungi.

Now it had long been known that the decomposition of timber from any cause might be impeded; and in the case of Dry Rot altogether prevented by imbuing the woody fibres with certain mineral solutions, which likewise diminish the inflammability of the timber.

A solution of corrosive sublimate (bichloride of mercury) was commonly employed as a preventive of dry rot even in the last century; but it was reserved for Mr. Kyan to improve and patent this application, after, he states, twenty years' experience. His process is analogous to tanning; but instead of acting with oak-bark on the gelatine of animal matter, he acts with corrosive sublimate on the albumen, one of the approximate principles of vegetable matter. The timber is placed in the solution, and in from seven to fourteen days the process is complete. It is, however, expensive; and although the preservative effects of Kyanising are complete, a less costly method was found in the process of Sir William Burnett, who, instead of bichloride of mercury, employs the less expensive, more fixed, and equally efficacious salt, *chloride of zinc*, which is not only a preservative but a disinfecting agent, and is now commonly employed. It renders timber almost incombustible.

The French journal *Cosmos* states that a simple method has been adopted in the ship-yards of Venice from time immemorial for testing the soundness of the timber. A person applies his ear to the middle of one end of the timber, while another strikes upon the opposite end. If the wood is sound and of good quality, the blow is very distinctly heard, however long the beam may be. If the wood is disaggregated by decay or otherwise, the sound will be for the most part destroyed.

THE CHEMISTRY OF WINE.

Mülder, the celebrated German chemist, has, in his work with the above title (published in 1858), ably illustrated the chemical knowledge of Wine. The composition, he tells us, differs according as the wine is red or not red. In the last-mentioned no particular colouring matters are found, and only a trace of tannic acid; in the former both are present. Alcohol and water are among the principal ingredients; then sugar, gum, extractive and albuminous matters; then free acids, such as tartaric, racemic, malic, and acetic acid; tartrate of potash, of lime, and of magnesia; sulphate of potash, common salt, and traces of phosphate of lime; also, and especially in cellared wines, substances which impart aroma, as œnanthic and acetic ethers, in variable proportions; and other volatile matters. In red wines, and in many others, a little iron; and, according to one statement, some alumina may also be detected. Lastly, the best wines contain a peculiar substance called Œnanthine.

Most of the properties of wine depend upon the sugar, alcohol, tartaric acid, and water, which exist together in it; that is, putting aside taste and smell as standards of comparison. The acid of wine appears to be its most constant ingredient, never falling below three grains, and seldom exceeding six grains, per ounce. The alcohol varies from nine per cent in the weaker Moselles and Hocks, to twenty-four per cent in the stronger Ports and Sherries. But the sugar varies most of all: there is none in Clarets, Burgundies, Hocks, and Moselles; in Sherries, from nine to twelve grains in an ounce; in Ports, from sixteen to thirty grains; Madeiras, twenty to sixty; and in Cyprus as much as one hundred grains in an ounce. As a further illustration, the only difference between Port and Sherry is the quantity of sugar contained in the Port.

Next to tartaric acid, the most important is tannic acid, or tannin. It is most abundant in red wines, but Mülder says he found it in all white wines. The *crust* which is thrown down by red wines is mainly owing to the presence of tannic acid, which, combining with the albuminous matters of the wine, forms an insoluble compound.

The preservation of the wine is, in a great measure, to be ascribed to tannic acid; for the albuminous matters, which are always combined with tannic acid in wine, are thus prevented from decomposition, and the principal cause of the wine spoiling is thereby checked. Wines, therefore, which are intended for exportation, or to be long cellared, must not be deprived of too much tannic acid by means of albumen or gelatine.

Most of the saline matters have no great effect upon the taste: potash is the most important, as it saturates a part of the tartaric acid, and remains in a state of solution. But tartrate and phosphate of lime, together with the small amount of common and other salts in the wine, have no great influence upon its flavour, colour, or smell. As distinctive marks of the genuineness of the wines, they are of the greatest value: this may be seen by comparing the ash of an adulterated with that of a genuine wine of the same kind as that under examination.

Upon the cause of the *bouquet* of wine, first described by Liebig and Pelouze, Professor Mülder says, the so called fusel oils have shed most light. They are "ethereal oils, a mixture of several liquids in which the solid substances called fatty acids are dissolved: this mixture may be obtained either by distilling large quantities of wine (as in brandy distilleries), or by subjecting the grape-skins, which have already fermented with the juice, to distillation. In this manner substances actually existing in and belonging to the wine were obtained in such abundance as to allow of the mixed bodies being separated, and their individual constituents separately analysed. The result has shown that many of these ingredients may be artificially imitated; and those who adulterate wine have therefore attempted to improve the less aromatic wines by the addition of some odoriferous substance."

Upon these substances, which form the *bouquet*, the real value of wines depends. The substance which gives the vinous odour is the œnanthic ether, a fetid, ethereal liquid, composed of carbon, hydrogen, and oxygen. The acetic ether is most commonly found in aromatic old wines. Professor Mülder traces it to the oxygen of the air dissolved in wine, and existing in the bottles, which changes alcohol into acetic ether. It can decompose œnanthic ether, separate œnanthic acid; and perhaps the acetic acid, assisted by the tartaric acid, etherises a portion of the alcohol. It is well known that acetic ether is formed, after a time, in absolute alcohol in which it did not previously exist. But the alcohol we are treating of here is not absolute, as it is diluted in wine. A decomposition of œnanthic ether by means of the œnanthic acid in wine seems to Professor Mülder, however, not improbable, as in proportion to the formation of acetic and compound ether in old wine will be the diminution of œnanthic ether. The aroma increases, and the disagreeable odour decreases.

The improvement of wines by keeping is thus explained. All wines contain odoriferous substances, necessarily the products of fermentation; but young wine contains such an excess of œnanthic ether as to make it offensive, and cause it to affect the head.

It is not till the wine has been some time in store, and other fragrant ethers have been engendered from œnanthic ether, that the original aroma of the grape-juice reappears, being no longer masked, but having its bouquet increased by other aromatic ingredients. This fundamental fact, that fetid œnanthic ether is first formed, and masks all other aroma, is true not only of ethereal oils which preëxist in grape-juice, but also of those fragrant ethers which we have treated of above. These are sometimes found in the fusel oils of younger wines, sometimes in those of bad wines. They are found at an early period, though in no very large quantities; but they cannot impart aroma to wine until the greatest portion of the œnanthic ether is decomposed. Œnanthic ether is generally supposed to occasion the vinous odour; but the truth is, it spoils the bouquet, and although it gives rise to many of the aromatic ingredients of cellared wine, so long as it predominates in the wine it is by no means fragrant. A thorough knowledge of chemistry is not sufficient to explain every thing which concerns the aroma of wine. It is well known in pharmacy and perfumery that fresh distilled waters have not a pleasant smell, particularly if they are prepared from fresh plants. They obtain the fragrance which characterises them after the lapse of time.

Professor Mülder treats of the *Diseases of Wine* under five separate heads: First, the turning, which darkens the colour and destroys the flavour: this is caused by decomposition of tartar. Secondly, ropiness, consisting in the formation of a vegetable mucus from the sugar of the wine: tartaric acid is one cause of this corruption also. Thirdly, bitterness, to which Burgundies are peculiarly liable: this is attributed, hypothetically, to the formation of citric ether; it arises from the sediment, and often disappears of itself; drawing off the wine in other casks is therefore a remedy; or young wine may be added. Acidification is a fourth form of disease: in weak wines contact with air at a high temperature will produce it; carbonated alkali, introduced in time, stops it; but the colour and flavour are impaired. Mouldiness consists in the production of mould-plants on the surface of the liquor: the admission of air encourages this disease, and the alcohol disappears in the process; but how the mould is formed science does not yet pretend to say.

Great mistakes are made in judging of wine merely *by its age*. It is the year or vintage, not the mere lapse of time, which stamps the value. Thus, hock of 1811 (the comet year), is more valuable than hock of 1801; and claret of 1834, than claret of 1824.

The nobler wines of the Rhine, and many of those of Bordeaux, are distinguished above all others by producing a minimum of after-effect. The quantity of wine consumed on the Rhine by persons of all ages, without perceptible injury to their mental and bodily health, is hardly credible. Gout and calculous diseases are nowhere more rare than in the district of the Rheingau, so highly favoured by nature. In no part of Germany do the apothecaries' establishments bring so low a price as in the rich cities on the Rhine; for there wine is the universal medicine for the healthy as well as the sick, it is considered as milk for the aged.—*Liebig's Familiar Letters.*

General Science.

SCIENCE OF LORD BACON.

The following account of Bacon's knowledge of what had been done in his own day, or before it, shows that he was not invariably observant or mindful of the labours of his predecessors. It is a collection of casual remarks by Mr. Spedding, in Mr. Ellis's several prefaces, in the latest edition of Bacon's Works.

Though he paid great attention to astronomy, discussed carefully the methods in which it ought to be studied, constructed for the satisfaction of his own mind an elaborate theory of the heavens, and listened eagerly for the news from the stars brought by Galileo's telescope, he appears to have been utterly ignorant of the discoveries which had just been made by Kepler's calculations. Though he complained in 1623 on the want of compendious methods for facilitating arithmetical computations, especially with regard to the doctrine of Series, and fully recognised the importance of them as an aid to physical inquiries, he does not say a word about Napier's Logarithms, which had been published only nine years before, and reprinted more than once in the interval. He complained that no considerable advance had been made in geometry beyond Euclid, without taking any notice of what had been done by Archimedes and Apollonius. He saw the importance of determining accurately the specific gravities of different substances, and himself attempted to form a table of them by a rude process of his own, without knowing of the more scientific though still imperfect methods previously employed by Archimedes, Ghetaldus, and Porta. He speaks of the εὕρηκα of Archimedes in a manner which implies that he did not clearly apprehend either the nature of the problem to be solved or the principles upon which the solution depended. In reviewing the progress of mechanics, he makes no mention of Archimedes himself, or of Stevinus, Galileo, Guldinus, or Ghetaldus. He makes no allusion to the theory of equilibrium. He observes that a ball of one pound weight will fall nearly as fast through the air as a ball of two, without alluding to the theory of the acceleration of falling bodies, which had been made known by Galileo more than thirty years before. He proposes an inquiry with regard to the lever,—namely, whether in a balance with arms of different length but equal weight the distance from the fulcrum has any effect upon the inclination, -though the theory of the lever was as well understood in his own time as it is now. In making an experiment of his own to ascertain the cause of the motion of a windmill, he overlooks an obvious circumstance which makes the experiment inconclusive, and an equally obvious variation of the same experiment, which would have shown him that his theory was false. He speaks of the poles of the earth as fixed in a manner which seems to imply that he was not acquainted with the precession of the equinoxes; and in another place, of the north pole being above and the south pole below, as a reason why in our hemisphere the north winds predominate over the south.*

THE QUADRATURE OF THE CIRCLE.

De Morgan, in his able Paper of "Impossible Problems," gives the following on the Quadrature or Squaring of the Circle, which has been a mathematical problem since the days of Euclid, and is not yet solved.

The Arithmetical Quadrature involves the determination of the circumference by a definite arithmetical multiplier which shall be perfectly accurate. Lambert proved that the multiplier must be an interminable decimal fraction. (See Legendre's *Geometry*, and in Brewster's translation of that work.) The arithmeticians have given plenty of approximate multipliers. The last and most accurate was that by Mr. W. Shanks, of Houghton-le-Spring, who gave the requisite multiplier to 607 decimal places, of which 441 were verified by Dr. Rutherford. To give an idea of the power of this multiplier, we must try to master such a supposition as the following:

There are living things on our globe so small that, if due proportion were observed, the corpuscles of their blood would be no more than a millionth of an inch in diameter. Suppose another globe like ours, but so much larger that our great globe itself is but fit to be a corpuscle in the blood of one of its animalcule; and call this the *first* globe above us. Let there be another globe so large that this first globe above us is but a corpuscle in the animalcule of that globe; and call this the *second* globe above us. Go on in this way until we come to the twentieth globe above us. Next, let the minute corpuscle on our globe be another globe like ours, with every thing in proportion; and call this the first globe below us. Take a blood-corpuscle from the animalcule of that globe, and make it the second globe below us. Then, if the inhabitants of the twentieth globe above us were to calculate the circumference of their globe from its diameter by the 607 decimals, their error of length could not be made visible to the inhabitants of the twentieth globe below us, unless their microscopes were relatively very much more powerful than ours.

By *Geometrical Quadrature* is meant the determination of a square equal to the circle, using only Euclid's allowance of means; that is, using only the straight line and circle, as in Euclid's first three postulates. On this matter, James Gregory, in 1668, published an asserted demonstration of the impossibility of the Geometrical Quadrature. The matter is so difficult, and the proofs of a negative are so slippery, that he would be bold man who would be very positive on the point, even thougl there are trains of reasoning, different from Gregory's, whicl render it in the highest degree improbable, which are, in fact all but demonstration themselves, that the Geometrical Quadrature is impossible.

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* Quoted in the *Athenæum*.

To say that a given problem cannot be solved because tw thousand years of trial have not succeeded, is unsafe ; for mor powerful means may be invented. But when the question is t solve a problem *with certain given means and no others*, it is no so unsafe to affirm that the problem is insoluble. By hypothesis we are to use no means except those which have been used fo two thousand years ; it becomes exceedingly probable that al which those means can do has been done, in a question whicl has been tried by hundreds of men of genius, patience, anc proved success in other things.

The limitation to Euclid's first three postulates is frequentl omitted ; and persons are led to conclude that mathematician have never shown how to square a circle, than which nothing can be more untrue ; and Mr. de Morgan questions whethe the above difficulties would ever have existed, if Euclid's ideas of solid geometry had been as well arranged as his ideas of plan geometry.

Montucla has published a history of the Researches on th Quadrature of the Circle (Paris, 1831), which contains beside the vagaries of the insufficiently informed, an account of th attempts of older days, which ended in useful discovery. In later times, the whole subject has lapsed into burlesque ; the few who have made rational attempts being lost in the crowd who have made absurd misconceptions of the problem. To square the circle has become a by-word, though many do not know the problem under a change of terms ; say the rectification of the circumference.

Strange as it may seem, this problem of the Quadrature of the Circle still engages attention ; and persons are found to believe that they have attained even the Arithmetical Quadrature. It has been stated in foreign newspapers, within these few years, that the British government does offer, and always has offered, a large reward for the solution of this problem. This, we need hardly say, is a complete mistake ; the government never, at any time, offered one farthing for the Quadrature of the Circle.

THE TRUE SOURCE OF MECHANICAL ENERGY.

Professor W. Thompson, in a paper read to the Royal Institution, states that it appears certain, from the most careful physiological researches, that *a living animal has not the power of originating mechanical energy;* and that all the work done by a living animal in the course of its life, and all the heat that has been emitted from it, together with the heat that would be obtained by burning the combustible matter which has been lost from its body during its life, and by burning its body after death,—make up altogether an exact equivalent to the heat that would be obtained by burning as much food as it has used during its life, and an amount of fuel that would generate as much heat as its body if burned immediately after birth.

PARADOXES OF ROTATORY MOTION.

A German philosopher, Ferrell, has by many experiments been led to the conclusion that the effect of communicating rapid rotatory motion is to diminish weight. By means of a horizontally suspended bar, with a wheel at one end, to which rotatory motion could be given, he showed that when the point of suspension was shifted so as to make the wheel-end the heavier, the horizontality of the bar was restored by communicating rapid motion to the wheel, and so remained as long as the wheel kept turning; but as the speed of rotation diminished, the wheel-end gradually dropped down. Instead of descending perpendicularly, however, it leaned on one side. Professor Powell has exhibited this phenomenon to the Royal Institution, and thus shown that a body rotating is lighter than a body at rest; and thus *a leg of mutton when roasting weighs more than when brought to table.* Prof. Powell also showed that in the Prussian rifles, with cylindrical bullets with conical apices, the directions varied with the amount of charge; when it was low, the missiles deviated to one side. This fact was experimentally illustrated by paper shuttlecocks and. cardboard bomerangs, the return of which to the point from which they were propelled is one of the paradoxes of rotatory motion. The Professor's explanation is, that when a body is acted on by two forces in different directions, the resulting motion is a compound of the two.

Prof. Powell believes that the precession of the equinoxes might be accounted for by certain paradoxes of rotatory motion. The star Alpha Draconis was to the ancients the Pole-Star, and was inclined to the earth at an angle of twenty-six degrees, exactly the inclinations of the Pyramids at the time they were built; and these stupendous relics of past ages might thus be regarded as gigantic observatories by which Pharaoh's astronomer-royal regulated his chronometers.

THE REAL WORKING FORCE OF A CLOCK.

Our clocks are driven by means of sinking weights, and our watches by means of the tension of springs. A weight which lies on the ground, an elastic spring which is without tension, can produce no effects; to obtain which we must first raise the weight or impart tension to the spring, which is accomplished when we wind up our clocks and watches. The man who winds the clock or watch communicates to the weight or to the spring a certain amount of power; and exactly so much as is thus communicated is gradually given out again during the twenty-four hours, the original force being thus slowly consumed to overcome the friction of the wheels and the resistance which the pendulum encounters from the air. The wheel-work of the clock, therefore, exhibits no working force which was not previously communicated to it, but simply distributes the force given to it uniformly over a long time.—*Prof. Helmholtz.*

FAILURE OF OLD MACHINES.

In all that belongs to the mere motion of machines and engines, representations of which were published in the 16th and 17th centuries, the greatest possible ingenuity and fertility of invention is displayed. But in all that concerns construction, framing, and adaptation of form and dimensions to resistances, strains, and the nature of the work, a total absence of principle and experience is manifested; so that it is apparent that these machines would act very well in the form of models; but that, if actually set to work, the most of them would knock themselves to pieces in a very short time.—*R. Willis, F.R.S.*

ECONOMY OF HIGH-PRESSURE STEAM.

It must appear obvious to every reflecting mind that steam generated under pressure, and compressed into one-fifth or one-sixth the space it formerly occupied, and that again applied to an engine of little more than one-third the bulk, must be a desideratum. Let us calculate, for example, the duty performed by, and the force applied to, one of the largest class of locomotive engines, travelling with a train at the rate of forty-five miles an hour, and we shall find the amount of power given out to exceed that of 700 horses, or as much as would be required to drive the machinery in some of our largest factories.

This extraordinary power is exemplified in the process of preparing peat. In Prussia, steam at 60 lbs. pressure is used and passed through pipes to obtain at least 600° of heat, and is then thrown into compressed peat, where it produces the effect of a "fiery sponge," robbing the peat of its water, carbonising the material, and effecting the complete distillation of many substances. The texture of the peat is so far changed that it takes fire by exposure to air, so that it is necessary to cool down the charcoal in an atmosphere of steam.

Here may be noticed two predictions of Steam-power which have been singularly verified. In Dr. Darwin's *Botanic Garden,* first published in 1789, but written, it is well known, at least twenty years before the date of its publication, occurs the following prediction respecting steam :

> "Soon shall thy arm, unconquered Steam, afar
> Drag the slow barge, or drive the rapid car;
> Or, on wide-waving wings expanded bear
> The flying chariot through the fields of air.*
> Fair crews triumphant leaning from above,
> Shall wave their fluttering 'kerchiefs as they move;
> Or warrior bands alarm the gaping crowd,
> And armies shrink beneath the shadowy cloud:
> So mighty Hercules, o'er many a clime
> Waved his huge mace in virtue's cause sublime;
> Unmeasured strength with early art combined,
> Awed, served, protected, and amazed mankind."

another and less widely known poem by the same author, *The Temple of Nature,* published in 1820, there occurs this complete anticipation and still more remarkable instance of scientific prevision. In a note to line 373, canto ii. of the poem, the author sets out with, "The progressive motion of fish beneath the water is produced principally by the undulation of their tails;" and after giving the rationale of the process, he goes on to say that "this power seems to be better adapted to push forward a body in the water than the oars of boats;" concluding with the query: "Might not some machinery resembling the tails of fish be placed behind a boat so as to be moved with greater effect than common oars, by the force of wind or steam?"

PERKINS' STEAM-GUNS.

These steam-engines (invented by Mr. Jacob Perkins) excited the greatest attention, in consequence of the notion that the expansive force of steam might be substituted for that of gunpowder in military operations. The principal points in which these Steam-Guns differ from those ordinarily used in warfare are, that, owing to the duration of the propelling force, they enable us to discharge in a short time a great number of balls; and, in consequence of the facility with which the tube may be turned on a swivel, the shower of balls may be directed in any direction that is desired. But it was found that these engines required complicated and ponderous apparatus, even when their size was only such as fitted them to discharge small shot; that a considerable time must elapse before the steam attained the necessary force to effect the discharge; and, lastly, that the force of percussion attained by the balls was less than that of similar balls projected by means of gunpowder. Prechtl has demonstrated that the effect of steam, under those circumstances in which it has yet been found, is not equal to that of gunpowder when applied to large shot.—*Prof. Peschel.*

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* Darwin projected an "aerial steam-carriage," in which he proposed to use wings similar to those of a bird, to which motion was to be given by a gigantic power worked by high-pressure steam, though the details of his plan were not bodied forth.

In 1841, M. Delecluze discovered, among the manuscripts of Leonardo da Vinci, an entry carrying a knowledge of the steam-engine applied to warfare to at least as far back as the fifteenth century. He has published in the *Artiste* a notice of the life of Leonardo, in which he adds a fac-simile of a page of one of his manuscripts, containing five pen-and-ink sketches of details of the apparatus of a Steam-Gun, with an explanatory note on what he designates the "Architonnere." The entry is as follows:

> Invention of Archimedes. The Architonnere is a machine of fine copper, which throws balls with a loud report and great force. It is used in the following manner: One-third of the instrument contains a large quantity of charcoal fire. When the water is well heated, a screw at the top of the vessel which contains the water must be made quite tight. On closing the screw above, all the water will escape below, will descend into the heated portion of the instrument, and be immediately converted into a vapour, so abundant and powerful that it is wonderful to see its force, and hear the noise it produces. This machine will carry a ball a talent in weight.

It is worthy of remark that Leonardo da Vinci, far from claiming the merit of this invention for himself, or the men of his time, attributes it to Archimedes.

The Steam-Gun of our time has been an exhibition-room wonder; and the prediction of the Duke of Wellington, that it would fail in warfare, has never been tested.

THE STEAM-HAMMER.

To the genius of James Watt may be traced the first idea of using a hammer in connection with the power of steam, although it was left for one of our own time practically to carry out the project. In Watt's patent of April 28, 1784, he proposes to apply "the power of steam or fire engines to the moving of heavy hammers, or stampers, for forging or stamping iron, copper, and other metals," without the intervention of rotative motions or wheels, by fixing the hammer either to the piston or piston-rod, or working-beam of the engine.

In 1842, Mr. James Nasmyth patented this gigantic yet manageable machine, which he has constructed for and distributed to all parts of the globe. It is now employed in all the large engineering establishments of Great Britain: by anchor-makers and engine-builders, and railway manufacturers, as well as for making up iron, either from scraps, old rails, hoops, or from the pile. Before the introduction of this machine to the smithy, the forging of large marine-engine shafts for ocean steamers was not only tedious but uncertain; for without blows of sufficient energy it was impossible to expel the scoriæ from between the bundles of iron rods to be welded into main-shafts. The Steam-Hammer is likewise employed in stamping out dish-covers and moulding and forming silver-plate.

Steam-Hammers are made of various powers to suit different kinds of work. The anvil is usually below the floor; the hammer is suspended from the piston-rod of the steam-engine, and the piston works in the cylinder placed at the top of the machine. By admitting the steam under the piston, the hammer is elevated to the desired height, and by its own gravity the hammer falls; but the fall may be regulated by the admission of steam. Every degree of blow is attainable, from that of merely cracking an egg-shell to that of a dead pressure of 500 tons. By aid of a powerful crane, a giant may be seen welding and forging a shaft weighing 16 tons, and 27 feet in length, as easily as a country smith would make a horseshoe. Notwithstanding the enormous mass of metal which the hammer contains, and though, at first sight, it resembles a piece of monumental work rather than a tool to be used in the manufacture of machinery, it is beautifully proportioned; it is as manageable as a child's toy, and works as smoothly as the mechanism of a chronometer.

ROMAN ROADS AND BRITISH RAILWAYS.

The formation and repair of Roads in Rome and its provinces were among the most important labours of the Roman emperors. Thus, a continuous roadway existed from the wall of Antoninus in North Britain to Rome, and thence to Jerusalem, a distance of 3655 miles, exclusive of a sea-passage of 85 miles. The Via Appia, one of the twenty-nine roads which diverged from the imperial city, well illustrates the character of the Roman roads. Comparing modern British railroads with these ancient ways, there is a general similarity in the directness of their course, their level surface, and the severance of natural obstacles in order to attain those objects; we have borrowed from the very language of old Rome the *station* and the *terminus;* and in some instances the rails are laid upon the roads of our conquerors. Yet one hundred such works as the great substructure of the Appian Way at Arici would hardly equal, in cubic contents and probable cost, the high-level bridge at Newcastle, the Tweed viaduct at Berwick, and the Britannia and Conway tubular bridges. But, in considering the enormous cost of these modern structures, it should be remembered that charges for land, law, and parliamentary expenses, were unknown to the Romans; and our superiority consists more in mental power and scientific knowledge than in the mere application of unskilful labour.

SILVER, GOLD, AND IRON.

So unimportant a part do Silver and Gold seem to perform in the economy of nature, that if they were annihilated it is probable that the world would go on as well without them. How different in these respects from Iron, and how much less, therefore, intrinsically valuable? Independently of their beauty, the only really valuable properties of Silver and Gold are the difficulty with which they are acted upon by heat and other extraneous agents,—properties which, if they were more abundant, would render them well adapted for a great many useful purposes.—*Prout's Bridgewater Treatise.*

WEAR OF MALLEABLE AND CAST IRON RAILS.

It is a curious and important fact, that not only are Malleable Rails more durable than those made with Cast iron, but that malleable rails, when in use, are less susceptible to the deteriorating influence of the atmosphere than the same rails would be if unused. A bar of wrought iron, if placed upon the ground alongside one of the same form and material in the railway in use, has been made to show this fact in a very striking manner. The former is continually throwing off scales of rust, while the latter continues almost wholly free from waste of that description. This curious fact was discovered by Mr. George Stephenson to depend on certain electric influences, communicated by the passage of the trains.

WHY IRON RAILWAYS DO NOT RUST.

Ritter has proved by experiment that Magnetism has the power of protecting iron from corrosion; and by this influence the rails in use on railways are protected from rust: both induced and permanent magnetism is thus produced in the rails, each rail being magnetic with polarity, and having from four to eight separate poles.

INVENTION OF THE SAW.

The invention of the Saw has been ascribed by Pliny to Dædalus; but it has been traced to much higher antiquity—the age of the fourth dynasty of Egypt. In sawing, the Egyptians used a large hand-saw: they frequently fixed the wood upright, secured by pins in lieu of a vice, or with pins passing through the piece of timber itself, in order to support the planks as they were cut apart; which is the practice of modern sawyers.—*Wilkinson.*

THE FIRST SAW-MILL.

The old mode of making boards was to split up the logs with wedges; and, inconvenient as the practice was, it was no easy matter to persuade the world that the thing could be done in any better way. Saw-mills were first used in Europe in the 15th century; and in the year 1555, an English ambassador, having seen a saw-mill in France, thought it a novelty which deserved a particular description. It is amusing to see how the aversion to labour-saving machinery has always agitated England. A Saw-mill was erected in Lambeth (on the site of Lambeth water-works) in Cromwell's time, and which he protected by Act of Parliament. Another Saw-mill was established by a Dutchman, in 1663; but the public outcry against the newfangled machine was so violent, that the proprietor was forced to decamp with more expedition than ever did Dutchman before. The evil was thus kept out of England for several years, or rather generations; but in 1768 an unluckly timber merchant, hoping that, after so long a time, the public would be less watchful of its interests, made a rash attempt to construct another mill. The guardians of the public welfare, however, were on the alert, and a conscientious mob at once collected and pulled the mill to pieces!

OAK AND CHESTNUT ROOFS.

Oak is often mistaken for chestnut. At a meeting of the Horticultural Society in 1854, for the purpose of comparison, specimens of the timber of our two English kinds of oak (*Quercus pedunculata* and *Quercus sessiliflora*) and of Spanish chestnut were furnished by the Vice-Secretary, in order to exhibit the difference that exists between the woods of the pedunculate and sessile-flowered oaks and chestnut, for which the timber of the last-named oak, when found in old buildings, has generally been mistaken. It was, however, proved by pieces of wood from Westminster Hall that the timber in the roof of that building is not chestnut, as is still by many believed, but sessile-flowered oak, which, although softer, more pliable, and easily worked, was stated to be in all respects superior to the now more common pedunculate kind. The roof of Westminster Hall was thoroughly repaired in 1820-21, when forty loads of oak, from old ships broken up in Portsmouth Dockyard, were used in renewing decayed parts, and completing the portion at the north end, where it had been left unfinished; the roof was also greatly strengthened by tension-rods added to the principals in 1851.

ORIGIN OF WOOLWICH ARSENAL.

The Military and Civil branches of the Office of Ordnance have been established at Woolwich since the accession of George I., when a singular train of circumstances led to the fixing on this spot for the naval and military depot, formerly called the Warren, but now the Royal Arsenal.

The original Foundry possessed by the Government for casting brass guns and howitzers was established in Upper Moorfields, London, near the site of the Tabernacle, where John Wesley preached; and which, from the circumstance of his having before preached beneath a shed in the Foundry itself, was formerly called by that name. The operation of casting the guns was then, as it still is, an object of curiosity; and many persons, even of the higher ranks, occasionally attended to see the process of running the fluid metal into the moulds.

About the year 1716, when Colonel Armstrong was surveyor-general of the ordnance, it was determined to re-cast the unserviceable cannon which had been taken from the French in the ten successful campaigns of the Great Duke of Marlborough, and which had hitherto been placed in front of the Foundry, and in the adjacent Artillery Ground. Upon the appointed day a great concourse of persons assembled to witness the operation, among whom were many of the nobility, general officers, &c., for whose reception galleries had been prepared near the furnace.

On the same day, a native of Schauffhausen in Switzerland, named Andrew Schalch (who, from a common law of his canton, which made it necessary for every person born there to travel for improvement in his profession during three years, had visited different foundries on the Continent, and at length reached England), was attracted to Moorfields Foundry at an early hour, and was suffered minutely to inspect the work then going on. Colonel Armstrong was himself present, when Schalch, being alarmed at some latent dampness which he had observed in the moulds, addressed him in French, and, after explaining his reasons for believing that an explosion would accompany the casting of the metal, warned him to retire from the impending danger. The Colonel, who at once comprehended the importance of Schalch's remarks, interrogated him with respect to his knowledge of the art, and found him perfectly conversant with all its principles. He therefore resolved to follow his advice, and quitted the Foundry with his own friends, and as many of the company as could be prevailed on to believe that danger really existed. Scarcely had they got to a sufficient distance, when the furnaces were opened, and the metal rushed into the moulds; the moisture of which, as Schalch had intimated, immediately occasioned a dreadful explosion: the water was converted into steam, and this, by its expansive force, caused the burning metal to dart out in every direction, so that part of the roof of the building was blown off, and the galleries fell. Most of the workmen were dreadfully burnt, some lives were lost, and many persons had their limbs broken.

A few days afterwards, an advertisement appeared in the public prints, stating, in substance, that "if the young foreigner who, in a conversation with Colonel Armstrong on the day of the accident at the Foundry in Moorfields, had suggested the probability of an explosion from the state of the moulds, would call on the Colonel at the Tower, the interview might conduce to his advantage." Schalch was informed of this intimation by an acquaintance; and he directly waited on Colonel Armstrong, who told him that "the Board of Ordnance had in contemplation to erect a new Foundry at a distance from the metropolis, and that he was authorised, through the representation which he had made of his conviction of his (Schalch's) ability, to offer him a commission to make choice of any spot within twelve miles of London for the erection of such a building (having proper reference to the extensive nature of the works, and carriage of the heavy materials), and also to engage him as superintendent of the whole concern."

This advantageous proposal was readily accepted by Schalch, who, having inspected various localities, at length fixed on the Warren (previously a rabbit-warren) at Woolwich as the most eligible situation. Here the new Foundry was erected; and the first specimens of ordnance cast by Schalch were so highly approved, that he was fixed in the office of Master Founder, and continued to hold that post for about sixty years, when he retired to Charlton. He died in 1776, when about the age of ninety, and lies buried in Woolwich churchyard. Some of the largest mortars in the Arsenal were cast under his direction, and bear his name. His attention and scientific knowledge were so successfully applied, that not a single accident happened during all the hazardous processes in which he was engaged during his long service. Such was the concatenation of circumstances that gave origin to the Royal Arsenal.

The extension of Woolwich Arsenal in our time has been on a stupendous scale; and in no department of the public service are the vast mechanical resources of the age employed with greater efficiency; yet, amidst its gigantic works, it is impossible to forget—notwithstanding the recent reorganisation of the gun-factories to bring out 1000 colossal guns in a year—the services of the young Schauffhausen engineer, who, a century and a half ago, by the seasonable combination of talent and opportunity, laid the foundation of the chief war establishment of the most powerful nation in the world.

FAILURE OF "LONG RANGES."

The published accounts of monster guns and enormous mortars may often have led to the question whether there is any reason in the nature of iron and gunpowder why you should not make a cannon as large as the Monument, and discharge a ball of any size to any distance. The answer appears to be, as to the size of the cannon itself, and consequently that of the ball, there is no limit at all, except in the difficulty of casting masses of iron of more than a very moderate thickness without imperfections of various kinds, which would burst the gun when fired with an enormous charge of powder.

The limit of distance to which a ball can be carried is determined by two principles. First, the resistance of the air to the passage of the ball increases more rapidly as the speed of the ball increases than the speed of the ball itself. So that if an enormous initial force were brought to bear on the ball at first starting, it would encounter so immense a resistance that the total result would appear to be inconsiderable. The resistance of the air in arresting the progress of a ball may be inferred from the fact, that a projectile which in our atmosphere ranges little more than two miles, would *in vacuo* have a range of more than sixty.

The other curious principle connected with the subject is that the efficiency of an explosive compound depends rather on its elasticity than its disruptive power. Elasticity is the gradual progressive development of force; and if a compound expends the whole of its force at once, it does not produce any thing like the effect which would follow upon a more gradual evolution of force, though the explosion might be less powerful. Fulminating silver, for example, would be a very bad substitute for gunpowder, even if any cannon could be found which would not burst to atoms on its explosion.

These considerations show, amongst other things, that it is impossible that immensely long ranges should ever be attained by increasing the initial force of a projectile, or by using explosive compounds stronger than gunpowder. Such results can only be obtained either by the principle of the rocket, or by the diminution of the resistance of the air by means of proper alterations in the forms of projectiles. One of the longest shots ever made was, according to Dr. Scoffern, something more than four miles. The projectile used was a shell filled with lead, which was fired from a fifty-six-pound gun.

FLOATING BRICKS.

Bricks which floated on water are mentioned by Posidonius, Strabo, and Vitruvius Pollio as having been made of an aluminous earth found in Spain, for building, on account of their lightness. Pliny also mentions a pumice-like earth possessing these properties. In 1791, Giovanni Fabroni formed floating bricks from a siliceous earth found at Santafiore in Tuscany; they were also such bad conductors of heat that they might be held by one end in the hand while the other end was red-hot; and similar bricks have been made from the siliceous earth dug on the borders of the Spree at Berlin; whereas floating bricks were hitherto thought to be "wonders of the ancients."

ANTIQUITY OF STENCIL.

In the *Philosophical Transactions* for 1738, vol. xl. p. 393, we read that Procopius, in his *Historia Arcana*, says, the Emperor Justinius, not being able to write his name, had a thin, smooth piece of board, through which were cut holes in the form of the four letters J. V. S. T., which, laid on the paper, served to direct the point of his pen; his hand was guided by another. Possibly, this may likewise have given the hint to the first of our card-makers, who painted their cards in the same manner, by plates of pewter or copper, or only pasteboard, with slits in them in forms of the figures that are to be painted on the cards. Such is the art of Stencil, which has been applied in our time to decorating the walls of rooms, as well as to the marking of linen.

THE HYDROSTATIC PRESS.

When Pascal, in 1653, was pursuing his experiments on the weight of the air, in order to determine the general conditions of the equilibrium of fluids, he supposed two unequal apertures to be made in a vessel filled with a fluid and closed on all sides. If two pistons are applied to these apertures, and pressed by forces proportional to the area of the apertures, the fluid will remain *in equilibrio.* Having established this truth, Pascal deduced from it the different cases of the equilibrium of fluids, and particularly with solid bodies, compressible and incompressible, when either partly or wholly immersed in them. But the most remarkable part of this discovery, and one which of itself would have immortalised him, is his application of the general principle to the construction of what he calls *the Mechanical Machine for multiplying forces,* an effect which he says may be produced to any extent we choose, as one man may by means of this machine raise a weight of any magnitude. This new machine is the *Hydrostatic* (or *Hydraulic*) *Press*, first introduced by Mr. Bramah in 1796.—*North British Review*, No. 2.

PNEUMATIC PILE-DRIVING.

This new method, by Potts, consists in sinking, as piles for bridge-piers, tubes by means of the air-pump, the tube or pile sinking as the exhausting process is continued; and the tubes being put down so that their heads are level, to them is fixed a cast-iron plate, on which the pier is built. The tubes have been increased to five and seven feet diameter, when the simple exhausting process not being sufficient to overcome the friction of the sides, another vessel is introduced between the tube and the air-pump; and this being first exhausted, a communication is opened between the tube and the exhausted vessel, when a double effect is produced—the excavating or exhausting process, as in the former instance, with the addition of a sudden blow on the head of the piles.

THE WATER-WORKS AT THE CRYSTAL PALACE, SYDENHAM.

The magnitude of this system of fountains may be conceived from the circumstance, that when the great waters are in full operation, there are 11,788 jets playing, and that the quantity of water simultaneously displayed in them is about 120,000 gallons per minute. The water is supplied from three different elevations, but principally from a reservoir containing about six and a half millions of gallons. The water is in part obtained from an Artesian Well, 575 feet deep, through clay and sand for 360 feet from the surface, and chalk for the remainder.

The water-towers raise a supply of water to such an elevation as to play jets to the height of 250 feet, or 48 feet higher than the London Monument. Each tower consists of 11 stories, and a chimney-shaft surrounded by 6 water columns; and round the chimney is a staircase of 404 steps. The extreme height of the chimney is 276 feet, and the cast-iron cap is 14 feet in height, by 16 feet in diameter. Each tower is strengthened by ten wrought-iron diaphragms, between the columns, tied together by iron rods. The columns communicate with the bottom of the tank, through the centre of which the chimney shafts go: each tank is 38 feet deep, and 47 feet diameter, and will contain 448,000 gallons, or about 2000 tons of water. The total weight on the foundation when the tank is full of water is 3000 tons. Each tower furnishes but one jet of water, the pressure on the square inch at the mouth of the jet being 262 lbs. The engineer of the towers was Mr. I. K. Brunel; and the whole of the works were designed by Sir Joseph Paxton, M.P.

STRENGTH OF PAPER.

In 1837, Mr. Cowper, during a lecture which he delivered before the Society of Arts, produced a quarto sheet of post writing-paper, the ends of which he had pasted together, thus forming an endless web. Into this web he inserted two rods of wood, to one of which was attached a half-hundred weight, and, taking the other in his hands, he raised the weight. With the same sheet, he observed, had been lifted off the ground a man who weighed 150 pounds. With a bank-note, Mr. Cowper also stated, could be lifted 18 pounds.

CIPHER-WRITING.

Mr. Babbage, in a communication to the Council of the Society of Arts, in 1855, offers the following remarks on "the fascinating art of deciphering."

"To contrive a cipher which cannot be deciphered is not a question of importance. To be really useful, the cipher must be capable of being easily and quickly written by the person using it, and as easily and quickly read by the person to whom it is addressed.

"The art of deciphering resembles that of picking locks. The greater number of locks can be picked, and the only question is, what time each requires.

"Mr. Hobbs, during the Exhibition of 1851, picked Bramah's challenge lock in about 56 hours.

"The performers in a celebrated robbery of a bank in Scotland spent three months in passing through three locks.

"The last inscrutable cipher I deciphered cost me thirty hours. Some have cost me four or five working days. A cipher deciphered in Paris, for the French Government, occupied its decipherer fully during several months.

"Any intelligent schoolboy can make a cipher which shall cost hours, and even days, for its solution; and it is a fact, that very clever men, who have not studied deciphering, have frequently invented ciphers which nothing (but their solution) could convince them were not inscrutable.

"Under these circumstances, decipherers have an understanding amongst themselves never to examine any challenge cipher unless the proposer has already proved his knowledge of the subject by having deciphered ciphers of admitted difficulty."

THE MANIFOLD LETTER-WRITER ANTICIPATED.

Sir William Petty, in his scheme to establish a Scientific Academy or College (the predecessor of that of the Royal Society), recommends writing to be multiplied by means of an instrument which he invented, and for which Parliament granted him a patent for seventeen years. He called it his art of double writing, and described the instrument as being of "small bulk and price, easily made, and very durable." This is the prototype of the "Manifold Letter-Writer" of modern times, which has merely accomplished what Sir William Petty effected in 1648. A full account of the invention is given in Ward's *Lives of the Gresham Professors*, p. 218.

WHITWORTH'S DIVIDING MACHINE.

This machine nas been exhibited in action by Mr. Whitworth to the Institution of Mechanical Engineers, showing that an advance of ·000001 inch (1-1,000,000th of an inch) was distinctly indicated by the gravity-piece becoming suspended instead of falling; and the turning back of the divided wheel through two divisions, representing ·000002 inch, was then sufficient to cause the gravity-piece to drop, and included consequently all the play in the four bearings of the two screws and two collars. Mr. Whitworth showed also that the fineness of measurement obtained by the machine was sufficient to detect the expansion in length of an inch bar caused by a momentary touch of the finger, the bar then measuring ·000001 inch longer than previously (the expansion of iron being about 1-150,000th of its length for each degree Fahr.; a rise of temperature of 1-7th of a degree expands an inch bar 1-1,000,000th of an inch). He stated that in his larger machine for measuring the standard yard, with a bar 36 inches long, the same amount of expansion was shown by the momentary contact of the finger-nail. The finest measurement required the precautions of freedom from dust and moisture in the atmosphere, and from any current of air interfering with uniformity of temperature; and the machine was therefore kept in its glass-case during the time of use, with an opening only sufficient for moving the micrometer wheel and lifting the gravity-piece; by sufficient care in these respects the measure of a space corresponding to half a division on the wheel, or 1-2,000,000th of an inch, had been rendered distinctly perceptible.

AMERICAN CHRONOMETER.

One of the New York Chronometers supplied to the Grinnell Arctic Expedition, after being subjected to the severest tests, yet was so exquisitely provided with adjustments and compensations for the very great extremes of temperature to which it had been subjected, that in a polar winter it was returned with a change in its daily rate, during a year and a half, of only the 18,000th part of one second in that time. The temperature registered during the winter in Wellington Straits was actually 46° below zero.

Horology has enabled us to discover that when the wind passes one mile per hour it is scarcely perceptible; while at the rate of one hundred miles per hour it acquires sufficient force to tear up trees and destroy the produce of the earth. Without the aid of a seconds clock, it would have been scarcely possible to ascertain that a cannon-ball flies at the rate of 600 feet in a second.

GROLLIER AND HIS CLOCKS.

At the close of the 16th century (1596), was born at Lyons Nicholas Grollier de Servière, whose career appears to have been a long life of ingenuity. He died in 1689. At the age of fourteen he served in the army in Italy, and lost an eye at the siege of Verceuil. He afterwards served in Flanders, whence he passed into Germany, entered the service of the Emperor Ferdinand, and distinguished himself at the battle of Prague. On his return to France, his knowledge of mathematics and mechanics enabled him to render considerable service to his country in the memorable sieges of the time of Louis XIV.

After many adventures, Grollier retired from the service, and amused himself by inventing and constructing curious clocks, models of floating-bridges, machines for raising water, and wheels for propelling boats, similar in action to the paddle-wheel now used in steam-boats, but worked by manual labour. These models, with various mechanical puzzles, and curious specimens of turning in ivory, formed a cabinet of curiosities at Lyons, a description of which was published by Grollier's grandson.

Mr. Adam Thompson, in his *Time and Time-keepers*, describes several of Grollier's clocks. In one, time was measured by the descent of a ball in a metal groove, twisted round columns supporting a dome: when the ball finished its descent, its weight, lifting a detent, discharged the wheel-work, giving motion to an Archimedean screw, which raised the ball to its former position, again to descend as before.

In another clock, the ball descended in diagonal lines on an inclined plane, the means of ascent in this case being hidden from the observer.

In the third clock, the ball was made to traverse within the bodies of two serpents, which, by a reciprocating motion, were made to swallow the ball alternately. A compound of the motions in the two last clocks (says Mr. Thompson) was adopted by a scientific gentleman about fifty years since; and time-pieces on this principle are called Congreve clocks.

Grollier made some of his clocks go by their own weight, descending inclined planes, and others in grooves, forming a path from the ceiling to the floor. When the clock had nearly finished its descent, it was lifted off, and again placed at the highest point of its path; when the clock was lifted, the hands were set to the proper time before it was again replaced.

Several clocks upon this principle have since been projected, some as novelties, and others for the purpose of avoiding the casualties to which main-springs and weight-lines are liable. A curiosity of this kind, made by Maurice Wheeler, was exhibited in Don Saltero's collection at Chelsea. The Marquis of Worcester is said to have invented another. And one invented by M. de Gennes indicated time by its *ascent* on an inclined plane; but this machine, as may be supposed, had a spring for its maintaining power. The clock was kept in equilibrium by a weight at the end of a lever; the unwinding of the springs made the weight change its position, thus changing the centre of gravity, and causing the clock to ascend the plane.

Various methods have been devised to supersede the going-weight and main-spring, and to renew with facility the maintaining power. One time-piece of this sort hung like a lamp from the ceiling, and was kept going by its own weight in descending. To renew the maintaining power (to wind it up), it was only necessary to raise or push it towards the ceiling, when it would continue to go as before.

Among other methods of showing time, Grollier contrived the following clocks to surprise his visitors. A small figure o a tortoise, dropped into a pewter plate filled with water, having the hours marked on the flat edge, would float round, and stop at the proper hour: if moved, it would again return; and i the tail were placed at the hour, it would turn round, and again point with the head.

A lizard was seen ascending a pillar on which the hour were marked, and pointing to the time as the day advanced.

The figure of a mouse was also made to move on a cornice and point to the hours marked upon it. These (says Mr Thompson) were simple contrivances, requiring but a littl address to give a hidden motion to a magnet: the intervening substances between it and the figure being thin, the attraction was sufficiently strong.

Scarcely any of Grollier's ingenious works now remain.

INVENTION OF THE SMOKE-JACK.

Heated air has been turned "to sundry pleasant uses, a for the moving of sails in a chimney-corner, the motion o which sails may be applied to the turning of spits, or the like." Thus writes Bishop Wilkins, adding: "But there is a better invention to this purpose, mentioned by Cardan, whereby a spit may be turned (without the help of weights) by the motion of the air that ascends the chimney; and it may be useful for the roasting of many or great joints: for as the fire must be increased according to the quantity of meat, so the force of the instrument may be augmented proportionably to the fire. In which contrivance there are these conveniences above the jacks of ordinary use: 1. It makes little or no noise in the motion. 2. It needs no winding up, but will constantly move of itself, while there is any fire to rarefy the air. 3. It is much cheaper than the other instruments that are commonly used to this purpose; there being required unto it only a pair of sails, which must be placed in that part of the chimney where it begins to be straitened; and one wheel, to the axis of which the spit-line must be fastened. (Here we have the ordinary Smoke-jack.)

"The motions of these sails may likewise be serviceable for sundry other purposes besides the turning of a spit: for the chiming of bells, or other musical devices; there cannot be any more pleasant contrivance for continual and cheap music. It may be useful also for the reeling of yarn, the rocking of a cradle, with divers the like domestic occasions."—*Mathematical Magic*, book ii.

The Bishop adds that Ctesibius made by this kind of motion his representations of living creatures, whether birds or beasts.

ANCHORS, ANCIENT AND MODERN.

The invention of the Anchor has been ascribed by some to the Tyrrhenians, by others to Midas, the son of Gordius, whose anchor, Pausanias tells us, was preserved till his days in one of Jupiter's temples.* The most ancient anchors were of stone, and sometimes of wood, to which a quantity of lead was fixed. Buckets full of stones and sacks full of sand were employed for the same use. These were let down by cords into the sea, and by their weight stayed the course of the ship. Afterwards, Anchors were made of iron, and furnished with teeth or flukes, at first one only: a second was added by Eupalamus or Anarcharsis, the Scythian philosopher. The anchors with two flukes, from ancient monuments, appear to have resembled those used in our days, except that the transverse piece of wood is wanting in all of them. Every ship had several anchors, the largest of which was termed *sacra*, and was never used but in extreme danger; whence *sacram anchoram solvere* is proverbially applied to such as are driven to their last refuge.

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* The anchor is mentioned at the opening and the close of the sixth Æneid of Virgil. Thus Æneas having reached the Cumæan shore,

"tum dente tenaci
Ancora fundabat naves."
("Their anchors dropp'd, his crew the vessels moor." *Dryden.*)

And the final line—

"Ancora de prorâ jacitur, stant litore puppes."
("At length on oozy ground his galleys moor;
Their heads are turned to sea, their stems to shore." *Dryden.*)

The ancients had anchors even in the time of Archimedes. The great galley of Hiero had four wooden and eight iron anchors. In the ship on board which St. Paul was a prisoner (described in the Acts), the sailors dropped four anchors from the stern, which, however opposed to modern usage, was undoubtedly the ancient method of letting the anchor fall at that period.

The Chinese, who may be supposed to adhere to ancient forms, are said to use chiefly crooked pieces of wood.

The improvement of the Anchor in modern time has received great attention from British manufacturers. In a grand trial of "Anchors of all Nations," made at the Royal Dockyard, Sheerness, Trotman's improved Norton's anchor, on the swivel principle, was shown to possess very considerably more holding property than any other anchor. In this improved anchor the arms or flukes are forged wholly independent of the shank, but are bolted to a pivot or fulcrum at the end, round which the flukes freely move, thus departing at once from the rigidity usual in the construction of anchors. The joint resembles that which connects the wires of an umbrella with the ribs, so that the flukes move round the pin or bolt as an axis; and when one fluke enters the ground, the other necessarily falls down upon the shank, thereby avoiding the danger incident to the upward projection of a sharp point. By this means is avoided "fouling," by the cable passing over the exposed fluke when the vessel is swinging in a tide-way, or injury in the event of the vessel falling upon her anchor. Of this kind is the large anchor of the *Great Eastern* steam-ship, which was manufactured at the Chester Works, Liverpool. This anchor weighs 6 tons 19 cwt. 2 qrs., and being of Trotman's patent, is equal to an ordinary anchor of 10 tons. The largest anchor used in the British navy is $4\frac{1}{2}$ to 5 tons, of the ordinary kind, and costing about 300*l*.

THE MAGIC WHIRLPOOL.

The singular property of camphor to rotate upon the surface of water is illustrated in the following experiments, abridged from the *Magazine of Popular Science,* vol. iii.

Fill a glass tumbler with water, throw upon its surface a few shavings of camphor, and they will instantly begin to move and acquire a motion both progressive and rotatory, which will continue for a considerable time. During these rotations, if the water be touched by any substance at all greasy, the floating particles will forcibly dart back, and, as if by a stroke of magic, be instantly deprived of their motion.

If the water be made hot, the motion of the camphor will be more rapid than in cold water, but will cease in proportionally less time. Thus, provide two glasses, one containing water at 58 degrees and the other at 210 degrees; place raspings of camphor upon each at the same time. The camphor in the first glass will rotate for about five hours, until all but a very minute portion has evaporated; but the rotation of the camphor in the hot water will last only nineteen minutes; about half the camphor will pass off, and the remaining pieces, instead of being dull, white, and opaque, will be vitreous and transparent, and evidently soaked with water. The gyrations, too, which at first will be very rapid, will gradually decline in velocity, until they become quite sluggish.

The stilling influence of oil upon waves has become proverbial:* the extraordinary manner in which a small quantity of oil instantly spreads over a very large surface of troubled water, and the stealthy manner in which even a rough wind glides over it, must have excited the admiration of all who have witnessed it.

By the same principle, a drop of oil may be made to stop the motion of the camphor as follows; throw some camphor, both in slices and in small particles, upon the surface of water, and while they are rotating, dip a glass rod into oil of turpentine, and allow a single drop thereof to trickle down the inner side of the glass to the surface of the water: the camphor will instantly dart to the opposite point of the liquid surface, and cease to rotate. If a piece of hard tallow or lard be employed, the motion of the camphor will be more slowly stopped than by oil or fluid grease, as the latter spreads over the surface of the water with greater rapidity.

If a few drops of sulphuric or muriatic acid be let fall into the water, they will gradually stop the motion of the camphor; but if camphor be dropped into nitric acid diluted with its own bulk of water, it will rotate rapidly for a few seconds, and then stop.

If a piece of the rotating camphor be attentively examined with a lens, the currents of the water can be well distinguished, jetting out chiefly from the corners of the camphor, and bearing it round with irregular force.

The currents, as given out by the camphor, may also be seen by means of the microscope; a drop or two of pure water being placed upon a slip of glass, with a particle of camphor floating upon it. By this means the currents may be detected, and it will be seen that they cause the rotations.

Or a flat watch-glass, called a *lunar*, may be employed, raised a few inches, and supported on a wire ring kept steady by thrusting one end into an upright piece of wood like a retort-stand. Then put the camphor and water in the watch-glass, and place under the frame a sheet of white paper, so that it may receive the shadow of the glass, camphor, &c., to be cast by a steady light placed above, and somewhat on one side of the watch-glass. On observing the shadow, which may be considered a magnified representation of the object itself, the rotations and currents can be distinguished.

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* See *Things not generally Known*, First Series, p. 26.

BLAZE-PROOF DRESSES.

The frequent accidents of ladies' dresses taking fire teach a lesson which must not be neglected; for nothing can be more simple than to render the fabrics of which dresses are made blaze-proof. The most delicate white cambric handkerchief, or fleecy gauze, or the finest lace, may, by simply soaking it in a weak solution of chloride of zinc, be so protected that if held in the flame of a candle it may be reduced to tinder without blazing.

Messrs. Versmann and Oppenheim, in a paper read before the British Association, show that sulphate of ammonia and tungstate of soda have the property of making linen and cotton fabrics uninflammable, and do not injure or discolour them in washing. Preparations of these salts are used in the Royal Laundry; and their general adoption would prevent a vast number of those dreadful accidents which now almost daily occur to children and others. MM. Doebereiner and Alsner, after discussing the merits of borax, alum, and soluble glass, for diminishing the combustibility of cotton tissues, recommend phosphate of ammonia, which is cheap, and can be easily combined with sal ammoniac, and introduced into the starch with which the tissues are prepared.

THE INVISIBLE DESPATCH.

Writing with rice-water, to be rendered visible by the application of iodine, was practised successfully in the correspondence with Jellalabad, in our last war with Afghanistan. The first letter of this kind was concealed in a quill. On opening it, a small paper was unfolded, on which appeared only the simple word "iodine." The magic liquid was applied, and therewith appeared an important despatch from Sir Robert Sale.

CURIOUS TRANSMUTATION.

It is perhaps difficult to believe that the same salt (common salt) should be a chloride of sodium in the hand and a muriate of soda in the mouth; but it is nevertheless true; nor is it more incredible than the change which sulphuret of potash undergoes by solution, the decomposition of which is rendered evident to the senses by the evolved sulphuretted hydrogen.—*Dr. Paris.*

ANNIHILATION OF THE SMELL OF MUSK.

Some years ago, the emulsion of bitter almonds was found to possess the property of annihilating the smell of musk, and most of the cyanic preparations evince the same power. According to M. Mertot, a druggist of Bayeux in Normandy, ergot of rye will produce the same effect. This he learned by having to prepare a number of pills containing both musk and ergot, when no sooner were the two substances mixed than the smell completely went off.

BOILING CHECKS FERMENTATION.

M. Renault, Director of the Veterinary School of Alfort, France, has shown that the baking and roasting of meats, and the boiling of liquids arising from animals affected with contagious diseases, have the effect of completely annihilating the virulent properties of these substances. The practical value of this fact will be appreciated by many of the inhabitants of large cities, who are obliged to use milk and some other articles of food which are not of the best quality.

DIRTY WINDOWS.

Every one has observed upon dirty windows in the metropolis small tree-like crystallisations : these consist of sulphate of ammonia, which is produced in the atmosphere by the burning of vast quantities of coal, combining with the sulphurous acid in the air.

THE CHEMISTRY OF MORTAR.

When limestone is burnt, the carbonic-acid gas is expelled from it, and there remains nothing but a pure alkaline earth. Then, if water be mixed with it, as in making mortar, the lime re-absorbs carbonic acid, acquires hardness, and again becomes limestone.

TO COVER LACE OR NET WITH COPPER.

This beautiful experiment can be performed by any person in possession of a simple galvanic battery. First, make a saturated solution of sulphate of copper in a vessel large enough to contain the net or lace that is to be experimented upon fully stretched out. Next stretch the net or lace upon a copper ring ; then dust it well over with the best black-lead, using a camel-hair brush to rub it into every part. This black-lead acts as a conductor to the electricity, when the net is attached to the battery. In fixing the apparatus the ring and net are to be attached to the wire in connection with the zinc end of the battery, and then perfectly immersed in the copper solution. A piece of copper attached to the wire in connection with the copper end of the battery must also be inserted in the decomposing vessel facing the net, not touching it ; this not only acts as a conductor, but also maintains the solution of copper of a permanent strength. In a short time the copper will be found to creep over the whole surface of the net. If desired, it may afterwards be gilt or silvered by the same process, provided that gold or silver be substituted where copper was previously used. We have little doubt that this experiment will eventually be of great service to commerce and the arts.—*Mining Journal.*

HEAT OF THE VAPOUR-BATH.

The late Baron Alderson, in a letter to his son, says: "I have been obliged at last to send for Sir Benjamin Brodie, to see me for my sciatica, and to-day, by his order, I have been stewed alive in a vapour-bath. Dreadfully hot, I can tell you—140 degrees, while a hot bath is only 98 degrees. Yet it was not unpleasant, after all: for hot air does not burn like hot water, as it communicates its heat gradually to you, air being what they call a bad conductor of heat. So, by the time the hot air makes you warm, a perspiration breaks out and cools you again. People have been known to bear 400 degrees of heat, without much inconvenience. Sir Francis Chantrey told me once he had gone into the oven where he baked his moulds, which is heated by a nearly red-hot plate at the bottom. He wore thick wooden shoes to protect his feet, and a flannel dress, and was able to bear it very well. That was a dead heat that would have baked a pie, and yet a man alive would not be heated much above blood-heat, or about 100 degrees. Is not this curious? Life is able, you see, to bear heat which would roast a dead body."

DROWSINESS FROM COLD.

Very striking and curious is the story of Dr. Solander's escape, when in company with Sir Joseph Banks among the hills of Terra del Fuego. They had walked a considerable way through swamps, when the weather became suddenly gloomy and cold, fierce blasts of wind driving the snow before it. Finding it impossible to reach the ships before night, they resolved to push on through another swamp into the shelter of a wood, where they might kindle a fire. Dr. Solander, well experienced in the effects of cold, addressed the men, and conjured them not to give way to sleepiness, but at all costs to keep in motion. "Whoever sits down," says he, "will sleep; and whoever sleeps will wake no more." Thus admonished and alarmed, they set forth once more; but in a little while the cold became so intense as to produce the most oppressive drowsiness. Dr. Solander was the first who found the inclination to sleep—against which he had warned the others so emphatically—too irresistible for him, and he insisted on being suffered to lie down. In vain Banks entreated and remonstrated; down he lay upon the snow, and it was with much difficulty that his friend kept him from sleeping. One of the black servants began to linger in the same manner. When told that if he did not go on he would inevitably be frozen to death, he answered that he desired nothing more than to lie down and die. Solander declared himself willing to go on, but said he must first take some sleep. It was impossible to carry these men, and they were therefore both suffered to lie down, and in a few minutes were in a profound sleep. Soon after, some of those who had been sent forward to kindle a fire returned with the welcome news that a fire awaited them a quarter of a mile off. Banks then happily succeeded in awaking Solander, who, although he had not been asleep five minutes, had almost lost the use of his limbs, and the flesh was so shrunk that the shoes fell from his feet. He consented to go forward with such assistance as could be given; but no attempts to rouse the black servant were successful, and he, with another black, died there. —*Fraser's Magazine.*

DOMESTIC HYGROMETER.

Mr. Smee, in his work on *Debility and Defective Nutrition* (the substance of his Hunterian Oration), dwells much on the importance of Fresh Air, saying, "It used to be the fashion to say that all airs were chemically the same; the discovery of ozone, and the effect of air upon the permagnate of potash, lately discovered by Dr. Angus Smith, sufficiently dispels this fallacy. The hygrometric state of the air, as to its wetness and dryness, is of consequence." Mr. Smee then describes a household instrument, of his contrivance, which will show by inspection, with sufficient accuracy, the state of any room, bed, or other situation. This instrument consists of vegetable parchment, invented by Mr. Gaines, and perfected by Mr. De la Rue. It is made by immersing blotting-paper in sulphuric acid of definite strength, by which it is immediately converted into a new material, named by Mr. Smee Ametastine, because it is highly unchangeable by chemical agents. This curious material contracts in a dry and expands in a moist atmosphere. By taking advantage of this property, Mr. Smee has constructed many forms of hygrometers, the most simple of which he expects will be the concomitant of the thermometer in every home, and prevent many a traveller from catching a severe rheumatism in a damp bed.

A Chapter on Chloroform.

The use of *Anæsthetics*, or substances for producing temporary insensibility to pain, appears to have been known and practised for ages before the organic chemistry of our own times enabled us to place pain completely under the dominion of the human will, by the discovery and use of Chloroform.

We learn from Dioscorides that eighteen centuries ago the root of the Mandrake steeped in wine was given "to cause insensibility to pain in those who are to be cut or cauterised; for, being thrown into a deep sleep, they do not perceive pain." According to Pliny, the juice of the mandrake was given for injuries inflicted by serpents, and before incisions or punctures were made in the body, "in order to ensure insensibility to pain." Indeed, for this last purpose, with some persons, the odour of it is quite sufficient to induce sleep."* Apuleius makes a similar statement as to the mandrake: "If any one is to have a limb mutilated, burnt, or sawn, he may drink half an ounce with wine, and whilst he sleeps the member may be cut off without any sense of pain."†

M. Stanislaus Julien has discovered that the Chinese, in the third century of our era, were in possession of an anæsthetic agent which they employed in the same manner as we use Chloroform and Ether for producing insensibility during surgical operations. In a biographical notice of Hoa-tho—who flourished under the dynasty of Wei, between the years 220 and 230 of our era—it is stated that *he gave to the sick a preparation of Chanvre (Ma-yo), who in a few moments became as insensible as one plunged in drunkenness or deprived of life:* then, according to the case, he made incisions, amputations, and the like. After a certain number of days, the patient found himself reëstablished without having experienced during the operation the slightest pain. It appears from the biography of Hân that this chanvre was prepared by boiling and distillation. This anæsthetic agent of the Chinese is set down as the Indian Hemp, which is taken even now by the Arabs to produce an agreeable drunkenness.

In a work on surgery by Theodric, who lived in the latter half of the thirteenth century, is mentioned "a flavour for performing surgical operations," made of opium, mulberry, henbane (*hyoscyamus*), hemlock (*cicuta*), mandrake, wood-ivy, lettuce, to be boiled until concentrated in a sponge, which, when wanted, is to be warmed, and "applied to the nostrils of him who is to be operated on, until he has fallen asleep; and so let the surgery be performed."

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* *Natural History*, book xxv. ch. 74. † *De Herbarum Virtutibus*, ch. 131.

Bulleyn, in 1579, describes "the possibility of setting patients into an anæsthetic state during lithotomy, &c.," by the use of mandrake; and Baptista Porta, in his *Natural Magic*, gives various recipes for medicines which produce sleep instantly, &c.; among which is the sleeping apple, made with mandrake, opium, &c., the smelling of which binds the eyes with a deep sleep. Now the mandrake, which figures so prominently in all these accounts, has long been a marvel;* but seeing that it belongs to the same genius as belladonna, which has a greater power of annulling sensibility than any plant in present use, unless it be aconite, it is not unlikely to possess the anæsthetic quality ascribed to it—at least to such an extent as to justify us in believing that surgical operations have been performed under its influence without conscious pain.†

The Greeks and Romans were acquainted with the narcotic and anæsthetic properties of Indian Hemp, just mentioned as employed by the Chinese. Herodotus describes the Scythians as inhaling the fumes of hemp-seed thrown upon red-hot stones; and Dr. Royle suggests that Indian Hemp may have been the assuager of grief, the *Nepenthe* of Homer, given by Helen to Telemachus in the house of Menelaus, stated to have been brought from Egyptian Thebes. Now Indian Hemp grows in Africa, and the *bang* prepared from it is taken by criminals who are condemned to suffer amputation; and Sir Joseph Banks tells us that "it is said to enable those miserables to bear the rough operations of an unfeeling executioner more than we Europeans can the keen knife of our most skilful surgeon." Dr. Daniel states that the Indian Hemp is smoked by the natives of Congo, Angola, and South Africa; the leaves, seeds, and flowers, called *Kief*, are used, pounded and mixed with a confection, a piece of which as large as a walnut will deprive a man of reason, and produce the most voluptuous sensations.

In India the hemp is equally celebrated; but the Hindoos do not appear to have ever used it as an anæsthetic during surgical operations. It has been found by Dr. Christison to produce a pleasant numbness, and to render touch and feeling gradually obtuse; so that the practice of anæsthesia, by means of Indian Hemp is credible.

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* See *Things not generally Known*, First Series, p. 102; *Popular Errors Explained*, p. 153.

† Dr. Chapman; *Westminster Review*, January 1859.

In 1784, Lassard, surgeon to the Hôpital de la Charité at Paris, recommended the employment of a narcotic previous to painful operations; and in 1782, Augustus, King of Poland, was surreptitiously narcotised by his favourite surgeon, Weiss, a pupil of Petit, at Paris, while a mortified part of his foot was cut off without pain or consciousness. In Guyot's *Causes Célèbres* it is told how the Countess St. Gerau, after nine hours' labour, was made to drink a potion, "which rendered her insensible till the following morning;" meanwhile the child was born, and surreptitiously conveyed away, its very existence being denied to her; but many years after it was, in a French court of law, proved to be her offspring.

Two centuries ago, Middleton, in his tragedy of *Women beware of Women*, published in 1657, thus directly alludes to the practice of anæsthesia in olden surgery:

> I'll imitate the pities of old surgeons
> To this lost limb, who, ere they show their art,
> *Cast one asleep, then cut the diseased part.*

Mesmerism has been employed as an anæsthetic agent in India, America, France, and England, with success; but its effectiveness is by no means uniform, as it succeeds much better with Orientals than Europeans. Only from the science of chemistry were the seekers after a perfect anæsthetic agent guided in the true direction. To the Pneumatic Chemistry of Black, Priestley, Cavendish, and Lavoisier (see *ante*, pp. 64-66 and 100, 101), succeeded the hope that by means of the inhalation of various kinds of gases, or by the practice of *Pneumatic Medicine*, as the new system was called, many maladies would become amenable to the power of the physician. A medical Pneumatic Institution was set up at Clifton, near Bristol, by Dr. Beddoes; and in 1799, Humphry Davy, who had just completed his apprenticeship, was appointed its superintendent. In a previous page (84) we have recorded how Davy breathed nitrous oxide, which he found to lessen the pain of cutting a wisdom-tooth; and although he did not succeed in establishing nitrous oxide as a medicinal agent, in describing the effects of this gas, he predicts, that, "as nitrous oxide, in its extensive operation, seems capable of destroying physical pain, it may probably be used with advantage during surgical operations in which no great effusion of blood takes place."* Nor was this an accidental conception of genius, but the result of ten months' experiments; so that Davy must be acknowledged as the originator of that prolific idea which has become one of the most glorious realities of the present century.† Davy also foretold that Pneumatic Chemistry, in its application, was an art in its infancy; and had his prophecy and precepts then been heeded,

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* Davy's *Collected Works*, vol. iii.

† *Westminster Review*, Jan. 1859.

"it is probable that pain would have been put into subjection to the intellect at the very beginning of this century."

Forty years had elapsed after Davy's announcement, when (in 1844) Horace Wells, a surgeon-dentist, of Hartford, Connecticut, United States, was present at a lecture at which, it is presumed, the effects of inhaling nitrous oxide were shown. Mr. Wells induced the lecturer to accompany him home, and let him (Wells) inhale the gas, while another dentist, Dr. Rigg, drew one of his teeth, without pain; and Mr. Wells, after recovering from the inhalation, exclaimed, "A new era in tooth-drawing!" He then made other experiments with various success; but a failure so annoyed him that he gave up practice as a dentist, became unsettled, came to England, returned to America, and at length died by his own hand, in January 1848. Within three months of this sad end of the discoverer, Dr. Bigelow, of Boston, U.S., removed a breast from a patient who had been rendered insensible by inhaling nitrous oxide, which induced the Doctor to predict: "Nitrous oxide is quite likely to prove a certain as well as a safe and agreeable anæsthetic agent."

Mr. G. T. Morton, Wells's pupil and partner, and Dr. Jackson, next took up the idea: Morton learned from Jackson the use of chloric ether as a local application; and since 1818* it had been known that the vapour of ether, if inhaled, would produce effects similar to those of nitrous oxide. After several attempts, Morton, on Sept. 30, 1846, by the inhalation of ether, made himself completely unconscious during eight minutes; in the evening he persuaded a patient to inhale ether from a handkerchief, and then extracted a bicuspid tooth, of which the patient knew nothing till he recovered his senses, and saw the tooth lying on the floor. He repeated his experiments on tooth-drawing under the influence of ether in several cases. Emboldened by success, he administered his remedy to a patient in the Massachusetts General Hospital, who was operated on while under its influence. The next day a large fatty tumour was removed from the arm of a patient under the same conditions. Both cases being successful, the remedy was afterwards frequently used.

Meanwhile, a few of the American medical journals condemned the discovery as quackery; but the English journals at once rightly appreciated it. However, in November 1846, the Paris surgeons received the announcement with all but indifference; and Velpeau declined to test its worth. In London it obtained a more speedy trial. Early in December, Dr. Boott received from Dr. Bigelow instances of the success of "the new anodyne process;" and on Dec. 9 a lady was etherised at Dr. Boott's house, and had a tooth extracted without pain. Mr. Liston, at University College Hospital, on Dec. 21, "amputated a thigh, and removed by evulsion *both sides* of the great toe-nail, without the patient being aware of what was doing, so far as regards pain:" he heard what was said, and was conscious, but felt neither the pain of the incisions nor that of tying the vessels. Next, a patient in the Royal Infirmary, Edinburgh, was etherised, and had a limb amputated by Dr. Duncan, "without the infliction of any pain." Experiments were then made in the London and provincial hospitals; evidence of success accumulated in America and Great Britain; and at length the two great Paris surgeons, Velpeau and Roux, averred, before the two Academies, that the discovery was "a glorious conquest for humanity."

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* In 1818, in a paper in the *Quarterly Journal of Science and Arts*, believed to have been written by Mr. Faraday, is described the great resemblance between the effects of the vapour of ether and those of nitrous-oxide gas.

Thus a new era was inaugurated in the science of surgery, both for operators and patients. A month after the first application of ether in England, Dr. Simpson, of Edinburgh, discovered that by its instrumentality the ordinary pains of maternity might be averted without danger. The remedy was used also with a greater or less degree of success in some of the most fearful and painful diseases, and by its aid many persons were rescued from certain death who must otherwise have undergone a difficult, painful, and most dangerous operation.

Ether, the first agent employed in this great revolution, is said to have been known to Raymond Lully and Basil Valentine, the alchemists. In 1540, Valerius Cordus described the method of making it,—the *Oleum Vitrioli dulce*, as he termed it. It consists of 4 atoms of carbon, 5 of hydrogen, and 1 of oxygen. It is usually procured by distilling common alcohol (the hydrated oxide of ethyle) with sulphuric acid: hence its usual name of sulphuric ether; its present chemical name is oxide of ethyle.

Ether was noticed as early as 1540 by pharmaceutical Chemists. Dr. Frobenius and Mr. Godfrey made several experiments on it before the Royal Society, as described in the *Philosophical Transactions* for 1730, when the term *Ether* was first adopted. Mr. Godfrey states, "that this liquor Æthereus was formerly very much esteemed and inquired into, doth clearly appear by an experiment I made formerly for my worthy Master Esquire Boyle, by the means of a metallick solution, namely, by the solution of crude mercury united with the *Phlogiston Vini*, or other vegetables; and this æther swam on the top of the solution, which I separated *per Tritorinus*. This is what I have done formerly in Esquire Boyle's laboratory; and Sir Isaac Newton was very well acquainted with it too, which, by reason of shortness of life, was not brought to a full end, to do it so readily in quantity." Dr. Frobenius, after describing various experiments, says: "Æther, then, is certainly the most noble, efficacious, and useful instrument in all Chymistry and Pharmacy; *Ubi enim ignis potentialis, ibi actuali non opus est,* inasmuch as essences and essential oils are extracted by it immediately, without so much as the mediation of fire, from woods, barks, roots, herbs, flowers, berries, seeds, &c., from animals, and their parts too."

Morton, the discoverer of etherisation, fell into poverty; but his partner Jackson claimed the whole merit. Chloroform quickly superseded ether, and Morton, who had, contrary to the usages of the profession, patented his discovery, found his patent valueless.

Another labourer in the field must be mentioned here. In 1846, news of the discovery reached England, when Dr. Snow, who had previously made numerous experiments in respiration and asphyxia, brought the administration of this new agent to great perfection. The ether practice of London went almost exclusively to him. He published a work embodying the whole of his experiences in etherisation; it was appreciated by the profession, and was selling largely, when the discovery of the application of chloroform threw ether into the shade and the book with it. Dr. Snow was soon satisfied of the greater practicability of chloroform: he at once commenced its use. He next began, in 1856, to experiment with amylene, first upon animals, and if these promised favourably, then upon man. Amylene did not answer his expectations, and he discontinued its use. He died convinced that, though he did not succeed in the object, an anæsthetic will ultimately be discovered which may be inhaled with absolute safety, and which will destroy common sensation without destroying consciousness.

In March 1847 M. Flourens caused animals to inhale pure chloroform, which rendered them insensible; but believing it to be a dangerous agent, he did not think of commending it for the prevention of human pain. Dr. Chapman says:

> Anæsthetic agents should only be administered by those who possess knowledge and experience of their properties. The very essence of anæsthesia consists of a partial arrest of the vital processes, and is, in fact, a stage on the way from life to death: only those agents which are capable of leading us along this solemn path, and which, having done so for a certain distance, will allow us to retrace our steps, are really endued with the power of saving us from pain.

The mixture improperly called Chloric Ether is simply a solution of chloroform in alcohol. Early in 1847, the late Mr. Jacob Bell demonstrated the anæsthetic power of this mixture; but it was Dr. Simpson, who, upon the suggestion of Mr. Waldie, of the Apothecaries' Hall of Liverpool, first tried chloroform undiluted, discovered the effects of its vapour, and then bound his name indissolubly with the greatest benefit ever conferred on man.

Chloroform was first obtained in 1831, by Guthrie, an American chemist, by distillation of chloride of lime and alcohol.

In 1834, it was examined by Dumas, who showed its real composition to be two atoms of carbon. one of hydrogen, and three of chlorine. From the red ant (*Formica rufa*) is obtained formic acid, consisting of two atoms of carbon, one of hydrogen, and three of oxygen (C2, HO3). The elements C2, H, are viewed as a hypothetical radical called *formyle*, which, being united with three equivalents of oxygen, forms the *teroxide of formyle*, or *formic*, or *formic acid*. Now, if for the three equivalents of oxygen three equivalents of chlorine were substituted, the product would be a *ter-chloride of formyle*. Such being Dumas's ingenious view of the constitution of this important substance, he very appropriately named it *Chloroform*.

Pure chloroform has a strong, fragrant, ethereal, apple-like odour, and a sweet penetrating taste. It freely dissolves sulphur, phosphorus, iodine, camphor, fats, wax, resins, and caoutchouc. No other liquid is so perfect a solvent of the latter substance, which is left unaltered by it on evaporation.—*Westminster Review*, Jan. 1859.

Thus has the practicability of surgical anæsthesia been established: its safety and expediency in women during childbirth are, however, much controverted.* It was at first supposed to be safer than ether, and was in many instances used with great recklessness, till the first death from chloroform occurred, near Newcastle, in January 1848.

Dr. Snow took notes of between three and four thousand cases in which he had administered chloroform himself. It has been used extensively in every hospital in Europe. It was the greatest boon to our poor wounded in the Crimea and India. The exhaustion of the stock of Chloroform in Lucknow is recorded at one of the greatest calamities in that fearful siege. No fatal case occurred from its frequent use in the Crimea. Dr. Snow could ascertain but fifty fatal cases throughout the world which could fairly be attributed to chloroform during ten years. For several years before his death he made about a thousand a year in fees for administering chloroform in private practice. He met with but one fatal case among the many thousands to whom he administered chloroform. The fatal effect is by paralysing the heart; but the chance of this result, with due care, is very small indeed: it has been compared with the chance of a fatal railway accident.

The effects of chloroform vapour on the Sensitive Plant are very striking; and it has been used to render Bees quiet and innocuous, and while in this state the honey is taken from them; in swarming, they have also been rendered manageable by chloroform.

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* See the elaborate paper from the *Westminster Review*, by Dr. Chapman, reprinted in a separate form. Williams and Norgate.

Appendix.

MERCURY, OR QUICKSILVER.*

This very remarkable metal, which possesses the singular property of being fluid at common temperatures, was known to the ancients. It often occurs in the native state. Its colour is similar to that of silver; hence the name *hydrargyrum*, from two Greek words signifying "water silver," and *argentum vivum*, quick or living silver; the term "vivum" signifying *quick*, an old Saxon word usually understood in that sense in Scriptural phraseology. Hence, also, the name of Mercury, given by the Alchemists. Quicksilver mines occur in comparatively few places: those of Almaden in Spain, and Idria in Carniola, are best known. Hungary and Transylvania also yield mercury: it has long been obtained in China and Japan and Peru; and recently it has been discovered in great abundance and in remarkable purity in California and Australia. The Chinese from their mercury produce the best vermilion; and both China and Japan are noted for their mirrors.

Mercury occasionally occurs in native globules in the sulphide, cinnabar, or vermilion; which Pliny states Callias, an Athenian, discovered the preparation of (B.C. 505). He also mentions the mines of Almaden, then producing 10,000 Roman pounds annually, though the supply was purposely limited. In 1833, these mines furnished annually nearly 2,244,000 lbs., employed 700 workmen underground, and 200 extracting the metal from the ore at the surface.

Formerly mercury was imported tied up in fresh sheep-skins, and packed in barrels; it is now brought in hammered iron bottles. When pure, its surface makes an excellent mirror: common glasses are coated with mercury spread upon tin-foil, with which it forms a solid amalgam. Mercury dissolves in this manner gold, silver, lead, and other metals; hence its use in extracting them from the ore. The amalgam of silver and copper is used for stopping hollow teeth. Mercury is extensively employed in medicine, as the subchloride, or calomel; triturated with chalk or magnesia, or confection of roses, it forms blue-pill; and the bichloride is corrosive sublimate.

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* This, and the three subsequent articles on Mercury, should have appeared in the section on "the Chemistry of Metals," pp. 102-127.

Mercury has long been used in medicine; but the opinion of the necessity for giving it in any quantity is now altogether exploded.

Pure mercury boils at 680°; its vapour is elastic, like that of water. Geoffroy, at the request of an alchemist, enclosed a quantity of mercury in a strong iron globe, secured by iron hoops, and put the globe into a furnace. Soon after it had acquired a red heat, it burst with great violence, and the mercury was completely dissipated.

Mercury is used in the thermometer as a measurer of temperature. Its boiling-point, as measured by its own expansion, is 680°, but by the expansion of air 662°. If a common thermometer be plunged into boiling mercury, it stands (according to Crichton) at 660°, so that the expansion of the glass is equivalent to 20°; and almost exactly counteracts the increase of the rate of expansion of the mercury. "The consequence," as Dr. Thomson says, "of this fortunate coincidence is, that an accurately graduated mercurial glass thermometer is an accurate measurer of the increase of temperature as high as the boiling-point of mercury, or to 662°." The effect of "the mercurial atmosphere" will be found described by Faraday at page 76. Several washes and other preparations of mercury were formerly employed as cosmetics; the making of which was a great scurce of gain to the empirical chemist, which practice has lasted to our day. Mercury has also been applied to the correction of errors of levelling. Thus, Professor Mitchell, of the United States, has a mode by which, through the means of cups of mercury placed on each pier of the transit instrument, connected by a tube of mercury, he can at each moment of observation determine the level-error of the axis of his transit.

THE FREEZING OF MERCURY.

The congelation of mercury was first effected by M. Braun, of St. Petersburg. On Dec. 14, 1759, the temperature of the air being 34°, M. Braun prepared a freezing mixture of nitrous acid and pounded ice, into which a thermometer being placed, sank to —69°. Then substituting snow for ice, he sank the thermometer to —100°, —244°, and finally to 350°. The mercury in the thermometer was then found to be fixed, and it remained so for more than twelve minutes: on employing a thermometer graduated only to 220°, the mercury collected in the bulb, and remained solid as before. On Dec. 25, M. Braun repeated his experiments: as soon as the mercury became fixed, he broke the bulb of the thermometer, and obtained the mercury in the form of a solid, shining, metallic mass, perfectly malleable, not quite so hard as lead, and to be cut with a knife.

The upper surface of the frozen lump of mercury was concave, and pieces of it sank in fluid mercury, indicating its great contraction.

These philosophers did not, however, determine the freezing-point of mercury, which was proved by a series of admirable experiments performed in Hudson's Bay, with instruments furnished by Mr. Cavendish.

These instruments consisted of a glass cylinder, partially filled with mercury, in which the bulb of a thermometer was placed so as not to touch the side of the vessel; this apparatus was surrounded by a mixture of snow and nitrous acid, when the mercury descended to 38·66°, where it remained stationary, showing this to be *the freezing-point of mercury.*

Mr. Cavendish subsequently showed that mercury in the act of freezing contracts nearly 1-23d of its whole bulk.—*Abridged from Tomlinson's Student's Manual of Natural Philosophy.*

THE QUICKSILVER MINES OF CALIFORNIA.

The mercury mines of Upper California are only exceeded in value by the gold diggings. Rocks and mountains entirely of cinnabar have been found, and the apparatus for obtaining the pure metal is as simple as that used 1800 years ago: at a common lime-kiln or blast-furnace, 2000 pounds of metal are said to be manufactured daily, and the average yield of metal 50 per cent. California itself affords a good market, large quantities of mercury being used in separating fine particles of gold from the sand and dirt, and which cannot be procured by washing. The aborigines are said to have known and resorted to these cinnabar deposits for centuries to procure colouring materials.

The richest mines, at New Almaden, have yielded from 29 to 72 per cent; and ten furnaces, very defective in operation, have produced from 30,000 to 35,000 lbs. of mercury weekly.

FULMINATING MERCURY.

This fulminate, which is less dangerous and violent than Fulminating Silver, is in great demand as an ingredient in the charge of *percussion-caps* now so generally adopted in gun-locks.

Fulminating Mercury was discovered in 1810 by the Hon. Edward Charles Howard. It is obtained from a solution of mercury in nitric acid mixed with alcohol.

When fulminating mercury is heated to between 300° and 400°, it explodes with a bright flame and much violence; and if substituted for gunpowder, its combustion is so rapid and sudden that, like other detonators of the same class, it bursts the gun without expelling the ball. But it also explodes by percussion and friction, and a little heap of it placed upon an anvil and sharply struck by a hammer, goes off with a deafening noise. Many hundredweights of this dangerous article are annually manufactured; it requires great care both in its production and transport.—*Brande's Lectures*, by Scoffern.

Frightful accidents have occurred in the preparation of this compound. On June 4, 1842, Mr. H. Hennell, the principal chemical operator to the Apothecaries' Company, met a terrific death in the laboratory-yard, by the explosion of between five and six pounds of fulminating mercury, which he was manufacturing for the East India Company.

WHAT IS CHAOS?

Chaos is that confusion in which matter lay when newly produced out of nothing at the beginning of the world, before God, by his almighty word, had put it into the order and condition which it assumed after the six days' creation. Chaos is represented by the ancients as the first principle, ovum, or seed, of nature and the world. All the sophists, sages, naturalists, philosophers, theologues, and poets, held that Chaos was the eldest and first principle, *τὸ ἀρχαῖον χάος*. The Barbarians, Phœnicians, Egyptians, Persians, and many other nations, all refer the origin of the world to a rude, mixed, confused mass of matter. The Greeks—Orpheus, Hesiod, Menander, Aristophanes, Euripides, and the writers of the Cyclic Poems—all speak of the first Chaos; while the Ionic and Platonic philosophers built the world out of it. The Stoics held, that as the world was first made of a Chaos, it shall at last be reduced to a Chaos; and that its periods and revolutions in the mean time are only transitions from one Chaos to another. Lastly, the Latins, as Ennius, Varro, Ovid, Lucretius, Statius, &c., were all of the same opinion. Nor is there any sect or nation whatsoever that does not derive their *διακόσμησις*, *the structure of the world*, from a Chaos.

The opinion first arose among the Barbarians, from whom it spread to the Greeks, and from the Greeks to the Romans and other nations. Dr. Burnet observes, that besides Aristotle and a few pseudo-Pythagoreans, nobody ever asserted that our world was always from eternity of the same nature, form, and structure, as at present; but that it had been the standing opinion of the wise men of all ages, that what we now call the *earth* was originally an unformed, indigested mass of heterogeneous matter called *Chaos*, and no more than the rudiments and materials of the present world.

It does not appear who first broached the notion of a Chaos. Moses, the oldest of all writers, derives the origin of this world from a confusion of matter, dark, void, deep, without form, which he calls *tohu bohu*, which is precisely the Chaos of the Greek and Barbarian philosophers. Moses goes no farther than the Chaos, nor tells us whence it took its origin, or whence arose its confused state; and where Moses stops, there precisely do all the rest. Dr. Burnet endeavours to show, that as the ancient philosophers who wrote of the cosmogony acknowledge a Chaos as the principle of the world, so the divines, or writers of the theogony, derive the origin or generation of their fabled gods from the same principle.—*Encycl. Brit.*

THE ARK OF NOAH.

In 1730, Dr. Stukeley wrote: "According to the calculations I have made, I find God Almighty ordered Noah to get the creatures into the Ark on Sunday, the 12th of October, the very day of the autumnal equinox of that year; and on this present day, on the Sunday sennight following (the 19th of October), that terrible catastrophe began, the moon being past her third quarter."

Sir Gardner Wilkinson, in his work *The Egyptians in the Time of the Pharaohs*, in speaking of the Ark, mentions a strange attempt to connect the name of Thebes with the Hebrew word *Thebeh*, and thence with the Ark of Noah; which is at once shown to be erroneous, from the name of that city being a corruption of the Egyptian *Apê*, or with the article *Tápê* (in the Memphitic dialect *thápê*), "the head," or "capital," converted by the Greeks into their own *Thêbai.*

PAST AND PRESENT AGE OF PLANTS AND ANIMALS.

From the age of plants and animals in the present day, we are not entitled to infer their age in primitive times. Without appealing to the influence of food, and climate, and soil, on the growth of animal and vegetable bodies, we find the truth of our position in the history of our own species. During the first 2000 years of the human era, the laws of vital organisation were entirely different from what they are in the present day. From Adam to Abraham, the age of man varied from 969 to 175 years, and gradually declined to the average of three score and ten; and, in like manner, the plants and animals of primeval times, when they were required as epochs in the chronology of creation, may have had a more luxuriant growth and a shorter existence.—*Sir David Brewster's "More Worlds than One."*

As regards the last 3000 years, it is not difficult to prove that during this period the usual duration of the life of man has remained the same, as we read in the ninetieth Psalm, "A Prayer of Moses, the man of God," in which it is expressly said that the age of man is 70, and sometimes reaches 80 years.

GREAT AGE OF THE PATRIARCHS.

In May 1858, at a meeting of the Royal Society of Literature, at which the Bishop of St. David's presided, Mr. Poole read a paper "On a Papyrus brought from Egypt some years since by M. Prisse," in which he showed that it was really a much more curious record than had been at first suspected by its discoverer, and that the Rev. Dunbar Heath had been the first scholar who had suggested the true character and value of its contents. Mr. Poole stated that the papyrus was written by a person called Ptah-hotp, the eldest son of the king, and that it is dated in the reign of Assa—about B.C. 1900. The writer addresses his son in a discourse of excellent moral instruction, conveyed in terse and vigorous language. He asserts that he is delivering "traditional wisdom," the "speech of the Past;" and his style is not unlike portions of the Book of Proverbs. It is remarkable that Osiris is the only one of the deities of the land who is directly mentioned, and that the word "God" is often used alone; and it is important to notice, that if, as is generally agreed, Ptah-hotp was the eldest son of the reigning monarch Assa, his father must have lived to the age of not less than 130 years, as Ptah-hotp states his own age at the time he wrote this document was 110 years. We have thus important evidence of the continuance within the historic period of the great age attributed in Holy Scripture to the early patriarchs. Mr. Poole further stated, that this king Assa was supposed to be either a very early Memphite king of the third dynasty, or a shepherd king of the fifteenth dynasty, who also reigned at Memphis: this latter view Mr. Poole himself holds, believing this king to be the same as Manetho's Assis.

THE MANUFACTURE OF IRON.—PP. 110-115.

By Mr. Bessemer's beautiful process, molten iron just from the cupola is converted, without fuel, and literally at a breath, into such steel as could not be made in many weeks upon the old method. The great improvement which we may expect in the manufacture of wrought iron is, in bringing it, by Mr. Bessemer's process, from cast iron directly into a malleable ingot, which may then be heated and afterwards rolled or hammered to any required form. The homogeneous irons, so called, are brought into the same condition by a very much more complicated and wasteful process. Before we can ever depend upon the integrity of large masses of malleable iron, we must be able to bring them at once from the fluid state into a form approximating to that which they are intended finally to have.—*The Engineer,* No. 225.

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